

# The Dynamic Architecture Maturity Matrix

## Assessment analysis and instrument validation



Name: Jurjen Schipper  
Thesis Number: IKU-0223360



**Universiteit Utrecht**



**SOGETI**



## General information

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Name thesis candidate: Jurjen Schipper  
Student number: 0223360  
Thesis Number: IKU-0223360  
E-mail address: jurjen.info@gmail.com

Master program: Business Informatics (MBI)  
Starting year at University: 2002

Name of organization: Sogeti Netherlands B.V.

External supervisor: dr. ir. M.E. van Steenbergen  
Thesis Committee: dr. R. Bos (daily supervisor)  
prof. dr. S. Brinkkemper (second supervisor)



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## Abstract

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The Dynamic Architecture Maturity Matrix (DyAMM) is used as an instrument to assess the level of Enterprise Architecture Maturity (EAM) in organizations. In the past years DyAMM has been applied to many organizations in the form of EAM assessments. This resulted in a collection of assessments containing valuable data. The data contains information with regard to general overall maturity of organizations, but also more detailed information on individual key areas of EA. This thesis presents an analysis of the assessment data, additionally the data has been used to analyze and validate the DyAMM instrument for anomalies. A literature study has been performed, together with different approaches of obtaining expert input, such as an expert panel session.

The analysis of the maturity assessments led to interesting results. The assessment data showed us that EA in these organizations is still in its early stages, and there is a considerable diversity in the individual scores of EA key areas. The validation of DyAMM resulted in several recommendations for improvement, however DyAMM has demonstrated to be a robust and useful EAM instrument.





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## Abbreviations

CMM	Capability Maturity Model
CMMI	Capability Maturity Model Integration
DoC	(United States) Department of Commerce
DyA	Dynamic Architecture
DyAMM	Dynamic Architecture Maturity Matrix
EA	Enterprise Architecture
EAAF	Enterprise Architecture Assessment Framework
EAM	Enterprise Architecture Maturity
EAMM	Enterprise Architecture Maturity Model
EAMMF	Enterprise Architecture Management Maturity Framework
EACMM	Enterprise Architecture Capability Maturity Model
E2AMM	Extended Enterprise Architecture Maturity Model
GAO	(United States) Government Accountability Office
IFEAD	Institute for Enterprise Architecture Developments
NASCIO	National Association of State Chief Information Officers
OMB	(The White House) Office of Management and Budget
QMMG	Quality Management Maturity Grid
TOGAF	The Open Group Architecture Framework





# 1. Introduction

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In every organization where information systems are being used, Enterprise Architecture (EA) is present in some appearance, but often it is not clear which role EA plays within the organization. Organizations can have different views on the importance of EA, therefore EA is applied in different ways adjusted to the situation at hand (Schekkerman, 2003). Although many strategy managers seem to be convinced that EA is important for their business, it is often not clear what the added value of an EA will be and which level of maturity EA has reached. Regarding EA there are many definitions, many views, many architecture domains. However there is hardly an integral and 'holistic' approach. Furthermore there is only little standardization regarding the instruments used. EA can be seen as a blue print for organizations, it describes the building blocks of the organization. It defines the structures and processes related to Information Technology (IT).

From existing literature it is clear that EA applied in organizations, can be categorized into different levels of maturity. There are many maturity models, which elaborate on the different levels of maturity. Some of these models have their own specific characteristics but most of them have many aspects in common (CMMI, 2002). One particular maturity model is part of the Dynamic Architecture (DyA) method (Van den Berg & Van Steenbergen, 2006). The Dynamic Architecture method describes a vision about the process of EA development within organizations and enterprises. It also describes a model for assigning maturity levels. DyA has been developed by Sogeti Netherlands B.V. and is used by other companies as a tool for EA.

Besides the field of EA, Sogeti is also very active in research on different IT related fields. It has its own Dutch research institute ViNT ('Verkenninginstituut Nieuwe Technologie') which is a R&D department of Sogeti. ViNT investigates new technologies and their relation to business processes. Furthermore Sogeti has developed several (well known) methods for the IT business, such as Tmap for testing purposes.

Together with Sogeti Netherlands B.V. my research will be focused on EA maturity. This thesis will discuss DyA and will give a scientific view on different aspects of the method especially in relation to EA maturity.

## 1.1 Problem description and relevance

DyA was first published in 2001 and later on in 2006 (Van den Berg & Van Steenberghe, 2006) an updated version was published. It has been carefully created and improved by professionals in the field of EA and is based on many years of experience. Practitioners have been carrying out the methodology successfully for several years now. Sogeti and other organizations have adapted DyA and implemented it, or parts of it, in their own organization.

DyA is also widely used to assess the maturity of the Enterprise Architecture. The method is applied on individual organizations and the use of DyA through the past years has generated much information about EA Maturity (EAM) in different types of organizations. However this information has never been collected in a structured way. The data generated from DyA assessments could be a valuable source of information about the maturity of different aspects of organizations. It can provide a picture of how far EA maturity is embedded in different types of organizations.

Elaborating on the previous paragraph, we have to stipulate that little research is conducted on the validation of the DyA methodology from a scientific point of view. It is desirable that DyA is being evaluated in order to assess its robustness as a reliable maturity model.

Hence, this research will investigate the research gap addressed above and will try to fill in the blanks. Subsequently, from this problem description a research objective is formulated. This will be further discussed in the next section.

## 1.2 Research Objective and research questions

The research project follows two paths:

- *to analyze* DyA especially where it concerns EA maturity; and
- *to validate* the DyA Maturity Matrix as a valuable instrument.

This approach can – to a large extent - be projected on the Empirical Cycle ('t Hart, 1998). The objective is to firstly analyze DyA maturity and by following the Empirical Cycle execute the validation process on the maturity matrix.

In figure 1.1 the Empirical Cycle is shown with the steps that were (partially) taken during the research process.

The Dynamic Architecture Maturity Matrix (DyAMM) should support the EA community in its efforts to assess and to develop the practice of EA in organizations. This research project will provide a contribution to this goal. Within the scope of this project, two research steps will be performed which are elaborated below.

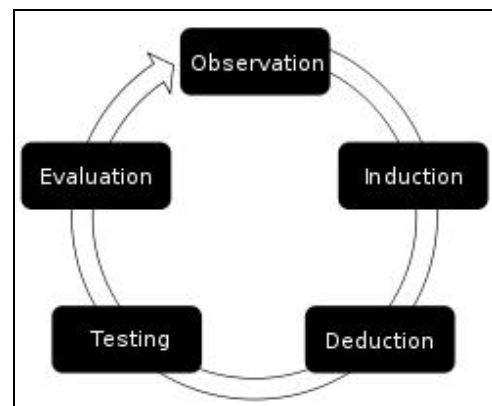


Figure 1.1: Empirical Cycle ('t Hart, 1998)

- 1) Analyzing assessment results from previous DyA architecture maturity assessments.

*The DyA architecture maturity matrix has been used as an instrument to assess the state of the architectural function in different organizations. This resulted in a large amount of data which is stored in assessment documents. By analyzing the data it is possible to look*

*for patterns and relations between architecture and for example organizational characteristics.*

2) Evaluation and validation of the Dynamic Architecture Maturity Matrix.

*Although the DyA model has been carefully constructed based on years of experience of (enterprise) architects there are some aspects that need attention. This step will address the following aspects:*

- *In all types of assessments it is important that questions are consistently verbalized (e.g. questions asked positive/negative) and without ambiguity (e.g. are questions interpreted the same way by different people). Since the assessment will concern different stakeholders, different views and different viewpoints it is important to use the appropriate terminology which can be understood and interpreted in a consistent way by all respondents.*
- *With respect to content, questions related to the maturity levels should be verified if they are actually relevant to the concerning maturity levels. On the other hand: are there other relevant questions missing?*
- *In the research domain of EA more and different maturity models are used. DyA will be compared with other maturity models in this field of research.*

Deducting from the research objective we formulate the following **main research question**:

*“What is the usefulness and added value of the Maturity Matrix? And therefore, what is the relevance of data generated from using the Dynamic Architecture Maturity Matrix as an instrument for assessment and improvement of the architecture process?”*

This main research question is supported by several **sub questions** which addresses the two research paths, analyzing and evaluation.

The Dynamic Architecture Maturity Matrix (DyAMM) has 18 so called ‘key areas’. These key areas each represent a different dimension within Enterprise Architecture Maturity (EAM). The DyAMM assessment method makes it possible to assess organizations on an overall maturity level and on a more specific level, namely the 18 individual key areas. The information for assessments is gathered through a survey containing 137 questions each related to one of the 18 key areas. With this information in mind, the following sub questions have been formulated.

Analyzing assessments results:

1. How mature are the assessed organizations with regard to EAM?
2. How do the assessed organizations perform on the 18 Key Areas with regard to EAM?

Evaluation and validation of DyAMM:

3. Are there anomalies with regard to the assessment questions, and with regard to the distribution of maturity levels on the 14 point scale? And if so, what is the impact of these anomalies?
4. Are there dependencies between different key areas?
5. Which key areas are most important when applying EA?
6. How does DyAMM compare to other maturity models?

### 1.3 Research contribution

Processes within organizations are becoming increasingly complex due to rapid developments in the application of information technology. Use of information technology creates new opportunities but should be introduced and implemented in a controlled and structured way. Architecture models and the architecture process play an important role when trying to control and structure information technology within organizations. This research contributes to the academic community and has social significance to the society in general.

#### Scientific relevance

Scientific relevance will be found in the deepening of the maturity assessment and a development of a more scientific grounded method. In particular the research will be relevant for determining the added value of the DyA Maturity Matrix and the generated data from maturity assessments for the architecture process. Additionally this project supports a PhD research into the effectiveness and continuity of the architecture practice in relation to organizational characteristics.

#### Social relevance

This research gives new insights in factors that affect the architecture and the architecture development process of business and information systems. It gives insight in the factors that affect the maturity level of an organization and the alignment between different aspects of EA within an organization. Organizations will get the opportunity to improve the effectiveness of their architecture function based on results from this scientific research. New understandings can contribute to a more mature implementation and usage of EA. Eventually this can result in qualitative or quantitative improvements for organizations, e.g. cost reductions and improved customer satisfaction.

### 1.4 Thesis structure

This thesis consists of seven chapters.

The first chapter gives an introduction to the research subject and describes relevant aspects of this research.

The second chapter describes the research methodology including the research approach.

The third chapter introduces the subject of EA, describing the *definition* and the *history* of developments within the field of EA. The EA process is also described together with an introduction to EA maturity.

Since this thesis is mainly focused on the maturity aspect of EA, chapter four is completely dedicated to maturity models and especially the DyA model that addresses maturity.

The fifth chapter describes all research results from both the analysis and the validation of DyAMM.

This thesis will be completed with two concluding chapters: chapter six presents general and specific conclusions and chapter seven presents a discussion which ideally should lead to further research.

## 2. Research Methodology

The first chapter started with an introduction to the research project with background information and the questions to be answered during this research. The next step is to explain the way this research was executed. Therefore this chapter firstly explains the research approach by means of a diagram. Each aspect of the research approach is explained in more depth in the different sections. The sections describe the research methods and the instruments used to obtain the research data.

### 2.1 General overview of research approach

Figure 2.1 proposes the research approach used during the research project. The model is visualized in a diagram which clarifies the overall research approach. The research approach basically consists of two parallel flows both starting from the general introduction of the subject.

On the left side the process of *literature research* is depicted which consists of two different stages each reflecting a certain aspect of the research project. The first stage describes the literature research with regard to the definitions, background information and maturity of EA, followed by a research on maturity models. The second part describes the research methods for qualitative and quantitative research. This process supports the *evaluation of DyAMM* on the right side. The right track is the actual research which consists of the analysis and validation of the DyAMM and the comparison of DyAMM with other maturity models. Both processes result in a final deliverable, a report which contains the research results gathered during the road to the final thesis report.

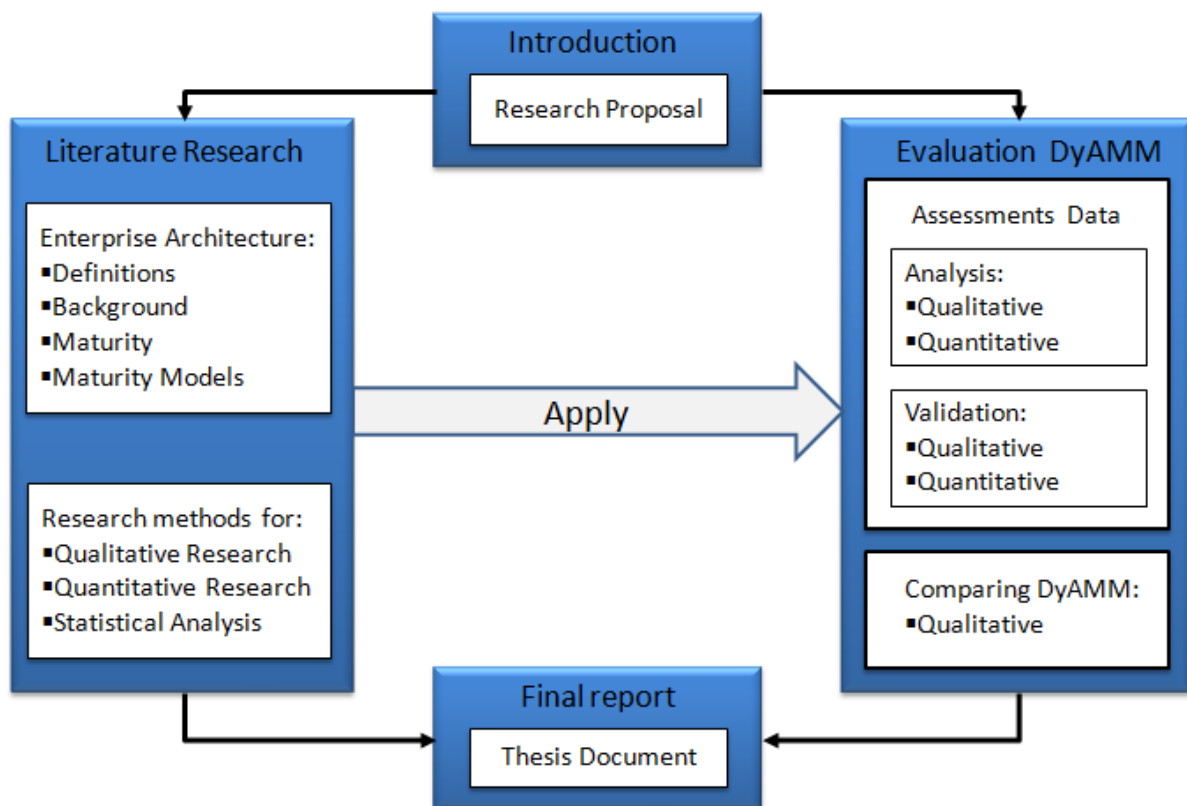


Figure 2.1: Research approach

## 2.2 Data gathering methods

The research approach is based on a number of different methods for acquiring research data. In this section the different methods are described. Section 2.2.2 can be read as an introduction to section 2.3, which further elaborates on the assessments and specifically the integral dataset of all gathered assessments.

### 2.2.1 Literature Research

The literature study is meant as a basis for the *Evaluation of DyAMM*. In the first place the *definitions* of EA are described to prevent ambiguity. Also subjects closely related to EA are brought up to explain the wider implications of enterprise architectures; for example the benefits, history of developments and maturity.

Besides a review of the subject related literature, also literature is reviewed with regard to the *relevant research* methods such as different statistical analysis and enquiry methods.

Although several books are available for DyA, extra attention will be given to this method. In this study the most important aspects and dimensions of the DyA model are described, the focus is particularly on DyAMM. A second literature subject is about the EA *maturity models* that are currently used in this market. Maturity models are described and compared to each other and more particularly with the DyAMM. Especially as far as they address alternative architecture maturity (assessment) models. The results are also used as input for the validation of the DyAMM.

### 2.2.2 Assessment collection

The most important part of the research project consists of analyzing data from maturity assessments performed by Sogeti. These assessments were executed before this research project took place. There was no structural approach of gathering and combining the assessment data. The assessments were not archived in a central place and have been performed over a period of several years. As far as possible all employees, who did execute the maturity assessments, were contacted. The assessments have been gathered and all assessments were inventoried and checked for missing data. The assessment data are a result of both formal and informal assessments, which may also influence the way assessments have been executed. This data had to be (re)organized and (re)structured so it will be accessible for analysis during the next phases.

The assessments that were gathered are combined into one dataset for statistical analysis. Section 2.5 will elaborate on the specific properties of the dataset.

### 2.2.3 Interviews

In order to collect the research data many people had to be contacted to check whether they were in possession of the maturity assessments. This gave also the opportunity to ask additional questions about the assessments they had executed within different organizations. This was necessary in order to assess the reliability of the assessment data and to gather more qualitative data for the validation of the maturity matrix. A simple informal interview and a questionnaire were constructed to quickly pinpoint if the assessments were qualified for use in this research. The interviews were also used to retrieve background information and opinions in the field of EA. This was very instructive, because many Enterprise Architects had several years of working experience in the field of information systems and EA. An example of a simple questionnaire is found in Appendix A.



### **2.2.4 Desk research**

Another part of data collection has been done through additional desk research, to collect data that was not available through assessments and interviews. This was mainly for finding more background information about EA maturity models and organizations that are actively participating in EA maturity models. For example online communities and organizations share their different opinions and views on EA, this gives alternative insights on the established literature in this specialism. Further the desk research was used to find missing and additional information about the organizations, such as organization characteristics (e.g. number of employees and industry sector).

## **2.3 Methods used for validating DyAMM**

The results found during the research have also been validated in order to check for faulty conclusions based on wrong results. Besides validating the results, also parts of DyAMM itself were validated during two sessions. For the validation process two expert meetings were organized. The first session was organized during a Competence Network Architecture (CNA) meeting at Sogeti. The second session was organized during an expert meeting at the University of Utrecht. This meeting was held in the so called 'Beleidslab', a computer supported conference room, this is explained in section 2.3.2.

### **2.3.1 Validation session: Competence Network Architecture**

The session was organized at the head office of Sogeti in Vianen and took around two hours. Fifteen professionals from Sogeti attended the workshop session. In essence the content is identical to the Beleidslab session at the University of Utrecht, which is elaborated in the next section. However this session was executed in the form of a presentation and workshop. The group consisted of different people with different skills, varying from technical oriented to business oriented architects.

The session was focused on the maturity matrix and contained three elements:

- the reviewing of questions;
- the prioritization of key areas;
- a discussion about the correlations between key areas.

The professionals were divided into three groups. Each group had its own private discussion with regard to questions that were asked in relation to the three elements. After each discussion the groups discussed in short their answers with the other groups.

The session was also used for fine tuning of the upcoming session in the Beleidslab. The questions related to the three elements and the time schedule for the Beleidslab session were optimized. The main focus for the validation session will be on the Beleidslab session. The following section will elaborate on this.

### **2.3.2 Validation session: Beleidslab**

Part of the research is a (partial) validation of the Maturity Matrix. In order to execute the validation, a group of Enterprise Architecture experts were invited to attend a two hour meeting. The goal of the meeting was to give feedback on several aspects of the research and if possible to validate certain observations.

The meeting was organized in the Beleidslab at the University of Utrecht. This is a specially designed environment for structured meetings with relative large groups of experts with a maximum of 15 persons. The environment consists of a conference room with 15 computers. All computer systems are linked together with GroupSystems MeetingRoom, which is collaboration software for supporting meetings. GroupSystems consists of several tools that

can support different group processes, for example brainstorming, organizing and prioritizing information (DeSanctis & Gallupe, 1987; GroupSystems MeetingRoom 2001).

The groupsystem has advantages above the traditional way of organizing meetings. It is possible to have a more structured meeting, which is more productive; and to have shared and parallel input, anonymity, complete and accurate record keeping of the session (GroupSystems MeetingRoom, 2001).



**Figure 2.2: Beleidslab Universiteit Utrecht**

The group consisted of 7 experts in the field of enterprise architecture. They all had several years of experience with EA, ranging from 4 to 17 years. These experts were employed by different organizations and companies, ranging from 600 to 65.000 employees and operating in different industry sectors.

The meeting was led by two people. One acted as a technical facilitator and had control over the groupware system. The other was in the lead with regard to content and was moderating the session.

The group did not get the opportunity to prepare themselves before the session. This was for reasons of having everyone at the same handicap level. The architects were familiar with the DyA method and the ins and outs of the maturity matrix.

The goal of the meeting was to get answers to the following questions:

- Which key areas are most important when applying EA?
- Are there dependencies between different key areas?
- Which assessment questions do affect the reliability of the assessment results in an undesirable way?

The order of questions as presented above does not correspond to the actual order that was used during the Beleidslab session.

Figure 2.3 shows the schedule that was used for the Beleidslab session. The execution of the meeting is explained in more detail below.



<u>Schedule Beleidslab session</u>	
<b>03:30 PM</b>	<b>Welcome</b>
<b>04:00 PM</b>	<b>Introduction</b> Presentation research, goal of today, introduction groupsystems
<b>04:20 PM</b>	<b>Short questionnaire (Survey)</b> A couple of background questions with regard to your organization
<b>04:30 PM</b>	<b>Selection of questions (Survey)</b> Analyzing a selection of questions which have a blocking effect of at least two levels for the key area concerned.
<b>05:00 PM</b>	<b>Prioritizing key areas (Survey)</b> Composing a priority list for the key areas
<b>05:20 PM</b>	<b>Correlations (Topic Commenter)</b> Search for possible explanations for correlations between key areas
<b>05:45 PM</b>	<b>Presentation of results</b> Presentation of the research results
<b>06:00 PM</b>	<b>Closing</b>

Figure 2.3: Schedule Beleidslab session

The meeting was structured in four parts. At the end of each part there was time for a short discussion in order to evaluate the answers of the experts. Hand-outs with a description of the maturity matrix were distributed among the participants.

*Part 1: The introduction.* During the introduction the goal of the meeting and the system were explained. The introduction also contained some general questions, for example about their organization and position. These questions were meant to get background information about the experts who attended the meeting and secondly to let the experts get acquainted with the system.

*Part 2: Selection of the questions.* During this stage four assessment questions were analyzed by the experts. The questions that were analyzed by the group, proposed a potential problem in DyA. Earlier analysis showed that these questions could possibly prevent organizations from moving up two maturity levels. The questions were selected based on the following condition: *A question that in at least 10% of the cases was answered with “No”, while if it were answered with “Yes” the organization would move up at least two maturity levels for the key area concerned.*

The *Survey tool* was used to ask questions with predefined answers, and to have the results immediately available for discussion. This survey tool has the ability to create a traditional survey, but with the advantage that answers can be monitored real time; and after completion of the survey can be immediately used for a group discussion.

*Part 3: Prioritizing key areas.* The third step was the prioritization of the key areas. The intent was to find out which key areas are the most relevant when developing architectures. This was done by defining a budget of 270,000 euro per expert. This amount had to be divided over the 18 key areas (15,000 euro per key area), keeping in mind that this amount represented time and energy to be spent in the *startup-phase* of an EA. This should give an indication of the relative importance of different key areas.

*Part 4: Brainstorming correlations.* During the research project some correlations were found. The correlations were presented to the group using the tool *topic commenter*. This tool gives all participants the opportunity to simultaneously comment on a specific topic. Everybody had to brainstorm individually by giving several ‘plausible’ explanations for these

correlations. At the end the correlations were shortly discussed in the group for extra feedback.

The session ended with a final presentation on the most important results found during the research. The full report of the session is available in Appendices B and C.

## 2.4 The DyAMM assessment

The DyAMM assessment is a questionnaire containing 137 questions related to EA maturity. Each question corresponds with one of the 18 key areas of the DyAMM. The number of questions associated to one key area ranges from 1 to 4. For each question there are two possible answers: yes or no. Example questions from the assessment are shown in figure 2.4.

	Questions	Fulfilled	Remarks
1	Is exchange of best practices supported by the organization?	Y	
2	Is frequent and systematic feedback on the architecture process given by the organization?	Y	
3	Are there any architecture tools in use that ensure the consistency between the various architecture artefacts?	N	

**Figure 2.4: Screenshot of DyAMM assessment questionnaire**

This is an example of a small part of the questionnaire that is presented to the candidates. It has to be noted that the questions in the questionnaire given to the candidates are mixed (randomized), in the sense that successive questions are not related to the same key areas. This is done because it could give the candidates hints about which key area they were answering to.

The assessment can be applied in two different settings: as an independent assessment (performed by DyA experts) or as a self assessment. The primary use of DyAMM is as an assessment instrument used by an independent assessor. The assessor usually enquires a person responsible for the architectural function. DyAMM can also be used as a self assessment tool, which can be completed by individuals for their own organization.

## 2.5 Sample description

In total 56 usable assessments were gathered. A handful assessments were not usable for this research because they were incomplete, thus lacking data essential for applying statistical tests. Initially the assessments were organized into two groups, *formal* and *informal* assessments. This division is based on the independent assessments performed by DyA experts (formal), as well as self assessments executed in the context of courses or workshops (informal). After statistical testing both groups with the *Independent Samples Test* (SPSS, 2006), it turned out that the results from both groups with regard to the scores on the key areas, did not significantly differ from each other, except the key area *Monitoring*. The results are presented in Appendix D. Since 17 of the 18 key areas were not significant different, we merged both groups. The final dataset consists of a total of 56 assessments executed over the period 2005-2007 in different countries (see also table 2.2). In table 2.1 an overview of the distribution of all assessments over the industry sectors is presented. The classification used is ISIC rev 3.1 from the UN Classifications Registry of the United Nations Statistics Division (United Nations Statistics Division, 2002).

<b>Sector</b>	<b>Number</b>	<b>Percentage</b>
Education	1	1.8
Electricity, gas and water supply	5	8.9
Financial intermediation	13	23.2
Health and social work	2	3.6
Manufacturing	8	14.3
Mining and quarrying	1	1.8
Public administration and defense	12	21.4
Real estate, renting and business activities	3	5.4
Transport, storage and communications	9	16.0
Wholesale and retail trade	2	3.6
<b>Total</b>	<b>56</b>	<b>100</b>

**Table 2.1: Distribution of organizations by industry sectors**

Table 2.1 shows that in this research the two sectors Financial intermediation and Public administration are represented by a significant higher number of assessments than the remaining sectors. A simple explanation could be that both sectors are really larger than the other sectors. According to architects within Sogeti the strong representation of financial intermediation is in line with a general higher enterprise architecture awareness that can be noticed in this sector and that is evidenced for instance by the frequent representation of this sector at enterprise architecture conferences. Also the high percentage of public administration is in line with an increasing demand by governments to apply enterprise architecture practices (Sogeti Architects, 2009; 2010).

Table 2.2 is a representation of the assessments distributed over the different countries. It shows that from all countries the Netherlands and Sweden are best represented. So these two countries were responsible for the largest part of data generated from the assessments.

<b>Country</b>	<b>Number</b>	<b>Percentage</b>
Belgium	2	3.6
Cyprus	1	1.8
Czech	1	1.8
Great Britain	1	1.8
Netherlands	40	71.4
Russia	1	1.8
Sweden	8	14.3
Slovakia	1	1.8
United States	1	1.8
<b>Total</b>	<b>56</b>	<b>100.0</b>

**Table 2.2: Distribution of organization by country**

Further analysis on the dataset is done by applying statistics. In this case the software package “Statistical Package for the Social Sciences” (SPSS) is used. In chapter 5 Results, the statistical approaches are more elaborated in combination with the findings from the assessment data. The analysis of the assessments show the level of EA maturity for these organizations. Also a more in depth analysis is given on the 18 specific key areas and this will show an overview of possible weaknesses on individual key areas.



## 3. Enterprise Architecture

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Enterprise Architecture (EA) includes many facets. This chapter will highlight on the most relevant aspects that are related to or have influence on EA and its value. In the first two sections EA is shortly introduced by describing the *definition* and the *history* of developments within the field of EA. The third section describes why EA is important for organizations, which benefits can be reached and what can be the *added value* for a business. The fourth section is on the EA *process* and identifies stakeholders that are involved in using EA. The last section is about EA *Maturity* (EAM). It is the introduction to the next chapters of this thesis which concern the results of the actual research.

### 3.1 Definitions

Enterprise Architecture is a term used by many professionals working in the field of Information Technology. After reading literature and listening to professionals it comes out that there is a lot of confusion with regard to the use of EA terminology. The term EA is explained in different ways and often misunderstood or even misused. This does not contribute to a positive image for the architecture community, the architecture competence and the value of the architecture deliverables.

At first a number of architecture definitions and explanations have been selected from literature. They address aspects that are relevant to take into consideration when talking about EA within a context of Information Technology. It will give a better explanation of the definition of EA used in this thesis and it will illustrate that the definition of EA can be approached from many different angles.

Several large organizations and institutes that are involved with EA have formulated terminology with regard to EA. The definitions shown below have been developed by organizations that define standards with regard to Information Technology and/or that have a long history in research and development focused on information systems. The organizations are well acknowledged in the IT business and therefore have a significant influence on developments in IT research.

The *Institute of Electrical and Electronics Engineers* (IEEE) has defined architecture in IEEE 1471 as a recognized standard: “The fundamental organization of a system embodied in its components, their relationships to each other and to the environment, and the principles guiding its design and evolution.”(Institute of Electrical and Electronics Engineers, 2000). This definition is the standard in this industry and is used as a basis for software and system architecture.

The *Software Engineering Institute* (SEI) defines architecture from the perspective of developing information technology systems: “A specification that identifies components and their associated functionality, describes connectivity of components, and describes the mapping of functionality onto components. Architectures can be of different types e.g. hardware, software, or system and can be domain-specific e.g. networking”. (SEI, 2006)

‘*The Rational Edge*’ (IBM) says an Enterprise Architecture can be defined as the: “blueprint that documents all the information systems within the enterprise, their relationships, and how they interact to fulfill the enterprises’ mission.” (West, Bittner & Glenn, 2002)

The central research question in this thesis is positioned around the Dynamic Architecture Maturity Matrix. DyA uses its own definition of Enterprise Architecture and is formulated by Wagter et al: “The consistent set of rules and models that guides the design and

implementation of processes, organizational structures, information, applications and the technical infrastructure within an organization.” (Van den Berg & Van Steenberghe, 2006)

A commonly used analogy with EA is the concept of architecture and buildings. The definition of EA from *‘The Rational Edge’* (IBM) uses the word *‘blueprint’* which is also used in the building industry. When constructing a building it is obvious that a building plan is needed in order to provide guidance and information for the actual construction of the building. The building plan can be seen as a blueprint being the basis for the construction of the building. When reasoning in these terms the concept of EA becomes more tangible. Within the context of an Enterprise and its related IT environment, EA can be understood to be a framework of principles and guidelines for the development of the Enterprise in terms of processes, organization, technology and IT in particular. Although EA usually does not specify the initial construction of an enterprise (such as a blueprint does for building construction), it does specify a framework for organizations through which they can develop and/or change the business environment in a controlled way.

As can be deduced from above sources, in current literature there is no final and consistent definition of EA. The professional community has not formulated a definition that is accepted by the community as a whole. Of course there are definitions set as an official standard, but many other factors play a role in the obscurity around architecture definitions. The practice of EA is relatively young and EA has a wide practice area and thus covers many dimensions and aspects. A lot of different definitions exist with a lot of ambiguity. However although the definitions can be at first sight quite different, they often describe similar key aspects of EA. Some aspects quite often referred to are: consistency, standards, processes and relationships between components. These aspects can be mapped on both technical and business architecture.

Even with such similarities between definitions, it will probably remain an endless discussion in the EA community about which definition covers the field of EA. It probably should be wiser to focus more on the scope of EA, because EA is very context dependent.

EA will be used on a high and abstract level. Therefore the definition of EA will mainly be related to the level of processes; in some cases when architecture is used on a different level, it will be further elaborated. The definition given by Wagter (DyA) with a sharp focus on business will be the principal definition for EA in this thesis. The definition is broader than the other definitions given by IEEE, SEI and IBM (focused on information systems and software) and covers a large part of the EA aspects discussed in this thesis. The definition given by Wagter (DyA) combines design and implementation of: processes, organizational structures, information, applications and the technical infrastructure. These are all key components for an EA.

## 3.2 History and evolution

In this section the history and development of EA will be described in short. Its purpose is to show how older models and theories have evolved through time and to show the status of the models used nowadays.

### *Zachmans framework, the origin*

The history of Enterprise Architecture goes back to the 1980s. It basically started in 1987, when John Zachman published the article “*A framework for information systems*” in the IBM Systems Journal. Zachman worked at IBM as a business systems planner. Zachman thought that business value and agility could best be realized from a holistic approach to systems

architecture that explicitly looked at every important issue from every important perspective. His approach was described as an ‘information systems architectural framework’ and soon renamed to be an ‘enterprise architecture framework’. This is the beginning of the development of an actual EA framework (Zachman, 1987). Zachman had a major influence on later developments in the field of EA. His framework is still being used and elements of his framework have been applied in other EA frameworks as well.

#### *US government, legislation*

One of the earliest practical and ‘business driven’ attempts to define an EA came from the US Government, the Department of Defense. The Technical Architecture Framework for Information Management (TAFIM) was introduced in 1994. The work done on TAFIM was taken over by The Open Group, transforming it into a new standard The Open Group Architectural Framework (TOGAF). Nowadays TOGAF is broadly used in the market as a standard for a methodology; TOGAF is commonly used as a basis for professional certification of enterprise architects.

In 1996 the US government put pressure on US agencies through the Clinger-Cohen Act. It demanded that all government agencies should have an IT architecture. This greatly stimulated the EA discipline, not only in the USA but it also had impact on the European market. In 1998 the CIO Council with the CIOs from all the major US governmental bodies began to work on the Federal Enterprise Architecture Framework (FEAF). They released a first version in 1999. From this moment US government bodies (e.g. Office of Management and Budget (OMB) and General Accounting Office (GAO)) developed a number of frameworks but progress was very slow. As the Office of Management and Budget (OMB) was becoming dominant in the public sector, Gartner became dominant in the private sector in 2005. Especially when Gartner took over The Meta Group it became a major player in the field of EA. Where Gartner focused on the framework itself, the Meta Group had its focus on processes. (Sessions, 2007)

At the beginning of the new millennium a trend of increasing regulations from governments and the market (especially aimed at financial organizations) becomes visible. In 2002 the Sarbanes-Oxley act pushed organizations to be stricter and to apply better governance practices. In 2004 the Basel II capital adequacy framework was established, putting extra requirements on risk measurement and management. This framework can be seen as a de facto standard for financial organizations. Both stimulate the application of EA further (Lankhorst, 2005). After the financial crisis and the resulting economic slowdown that occurred between 2007 and 2009, governments demand an even stricter regulation of the financial markets. At the moment of writing Basel III is in development.

Developing EA frameworks initially was mainly done by government organizations. However starting from the mid 90s several commercial organizations started to adopt the EA frameworks and developed their own vision on EA. A logical result was that new EA frameworks were constructed based on different theories. As can be seen in figure 3.1 this resulted in many frameworks with different approaches to EA.

#### *Change in focus*

Figure 3.1 contains a lot of arrows, colored boxes and relations; but that is not why it has been included in this thesis. The main purpose of the figure in this thesis is to show the wide variety of models in the field of EA frameworks that started with the publications of Zachman in 1987. The figure shows a timeline which summarizes the history of EA developments between 1985 and 2005. The timeline is a snapshot of some well known EA frameworks. It becomes clear from the timeline that many frameworks have been developed during the last

two decades. The figure also shows that many frameworks were influenced by preceding frameworks, and in some cases were a consolidation of different frameworks. The versatility in available frameworks also means there is a versatility in purpose, scope, principles, structures and approaches (Schekkerman, 2004).

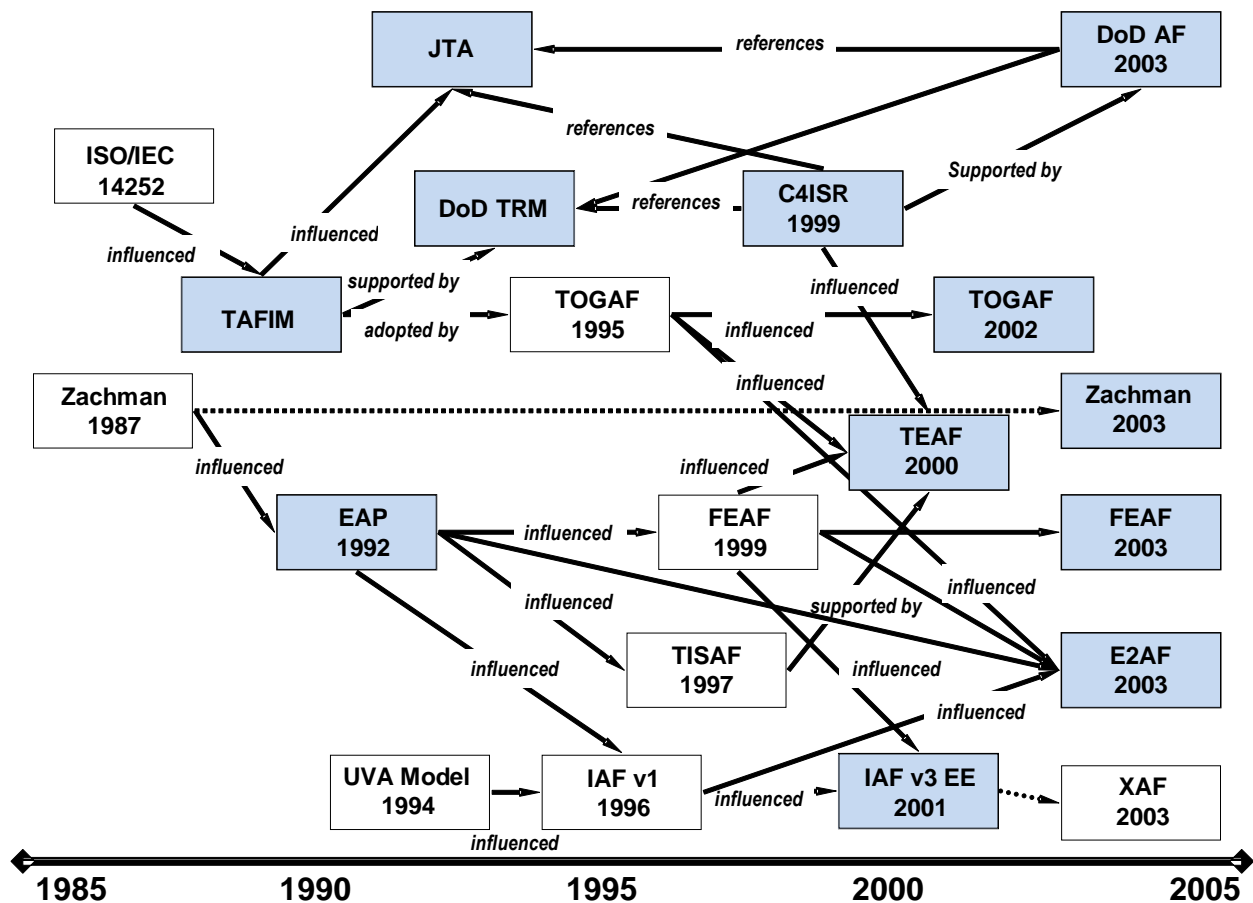


Figure 3.1: History of the development of EA frameworks (Schekkerman, 2004)

The field of EA is gaining acceptance, especially the last few years it has evolved steadily. This is not only on the business side, but also the research on EA is increasing (Langenberg & Wegmann, 2004). In the beginning EA was focused on information systems and had an IT-centric view, this gradually changed over the years. During recent years EA is shifting to strategic management, clearly it is now more business-processes oriented (Vaidyanathan, 2005). It evolves into an instrument used within the context of (IT) Governance. In other words you may say that the field of EA is changing into an increasingly mature field of business and scientific research.

In this trend of maturing of EA some organizations try to put EA frameworks onto a more professional level. A good example is The Open Group Architecture Framework (TOGAF), being an open source EA development. Many organizations and professionals are involved in this research project. TOGAF has been in development since 1995 and is based on the Technical Architecture Framework for Information Management (TAFIM), developed by the US Department of Defense. It contains a detailed method and a set of supporting tools for the development of EA. TOGAF is constantly in development and has evolved from a mainly technical oriented architecture to an overall EA, also including the Business Architecture, Data Architecture, and Application Architecture (The Open Group, 2011).



Since 2001 the Dynamic Architecture (DyA) method has been developed by Sogeti. This method also has a broad view on EA (business, information and technical). DyA was originally focused on the Dutch market. Although it is mainly used on the Dutch market, it has also been applied in many organizations in Sweden and the Benelux.

With so many resources invested in EA frameworks it becomes increasingly important to show the business the added value and benefits of EA frameworks.

### **3.3 Added value and benefits**

This thesis is not about promoting EA being the ‘holy grail’ for all business and IT related issues. This section is written to highlight some of the benefits of EA in order to nuance the arguments often used for ignoring an EA. Common arguments used are: it is too expensive, time consuming, and it takes too long for actually delivering a measurable result i.e. it is too far from practical use. However beyond any doubt EA - when understood and applied properly - is developing into an instrument for guidance when structuring and restructuring the Enterprise as a whole: its organization, its processes and its technology in mutual cohesion. It gives a useful framework for assessment of the functionality and the construction of an Enterprise in its different stages of development.

Many Enterprise Architects argue that practising EA has important benefits for organizations but often real benefits are not clearly specified. During the 1980s (Enterprise) Architecture was focused on Information Technology: architecture should simply lead to cost savings. Nowadays where business and technology are strongly related to each other the issue is how to handle increasing complexity of business processes, applications and technical infrastructure. This makes it even more difficult to practise EA and to identify the real benefits (Lapkin, 2005). Implementing and using an EA within an organization, understanding it and accepting its guidance will have a major impact on the organization. It asks for a change of attitude and it will drastically change the way organizations operate. Besides it can be very demanding on resources in terms of time, money, facilities and tooling. As mentioned in the previous section EA is shifting to the level of strategic management (Vaidyanathan, 2005). Therefore it is important that all stakeholders affected by this change - e.g. corporate management, business professionals, IT professionals, development disciplines and program and project management - need to be convinced of the added value of an EA. Of course not every organization should or even can start with the implementation of an EA.

In general terms an Enterprise and its IT systems when (re)designed and (re)constructed ‘under architecture’ will show improved qualities: easier to operate, easier to maintain, more flexible when changes are required, consistency when implementing changes, business continuity and reliable services. This leads to more control (projects and programs), lower cost (efficiency), better service (reliable, performance and user friendly processes and systems) and higher business values (time to market). (Aziz & Obitz, 2007; Obitz & Babu, 2009; Suter, 2007)

According to (Guevara, 2006) an EA which is designed properly and implemented correctly can speed up “time-to-market, reduce IT costs, integrate business processes, and create a common standard for how all IT groups use, extend, and manage a company’s IT systems, processes, and people”. (Guevara, 2006)

During the 80’s when John Zachman wrote about architecture, his research on a framework was especially focused on information systems. Nowadays architecture is presented from more viewpoints. Although the framework of Zachman is primarily focused on information systems it identifies and describes many aspects from a broader view on EA, e.g. the more organizational characteristics of EA.

Zachman writes about “*alignment*” (the popular term: business-IT alignment). EA can improve the value of IT with regard to supporting and achieving business goals by adding more business related views to the model.

Zachman mentioned “*integration*”, which according to Zachman will lead to a more market driven enterprise. Integration means that knowledge of the organization is not limited to a few employees, but it is becoming available enterprise wide and in some cases even available to customers.

Zachman talks about “*change*”. He compares the situation of an organization with physical objects such as buildings. When a building has to be changed in some way, drawings and documentation of the building are needed to efficiently and safely change the building. This principle also applies to changing organizations. Changing organizational structures (like is done with Business Process Reengineering (BPR)) ‘controlled’ by an EA will minimize time and costs.

Finally a more production focused benefit is the reduced “*time to market*” by using architecture in identifying or designing reusable building blocks and components.

IT and Business related benefits were also presented in a paper describing frameworks for EA by Shah & El Kourdi in 2007. They mention that a well documented EA enables faster adaptability. It will facilitate the knowledge acquisition that is necessary for changing systems and adopting new components. Proper use of EA frameworks will lead to improvement of operating procedures by modeling and understanding business processes and reviewing and reengineering these processes in accordance with architecture guidelines. A third aspect is better decision making. The enterprise’s layers and components are represented modularly to let the organization make business decisions within the context of a whole instead of an isolated part.

Finally several sources describe the aspect of “*agility*”. Agility is important in fast changing markets. Organizations need to be able to change and adapt quickly in order to survive the competition. According to Tucker & Aron 2005 EA can increase agility by reducing complexity, which is a major barrier to change.

In the beginning EA benefits mainly had their effect on Information Technology resulting in ‘simple’ cost savings. But as EA is shifting more and more to a strategic level, benefits will also become visible on a much wider scale, having bigger impact on the organization as a whole.

### 3.4 Development Process and Product

It is important to discern two aspects when using the term EA. One is the *process* of developing an Enterprise Architecture. The other is the set of *deliverables* that comes from this process and which is documenting the actual Architecture of the Enterprise.

When talking about Enterprise Architecture definitions it is easy to draw an analogy with building a house. But where the construction of a building usually at one time is finished, EA moves on after the initial delivery of the product. EA can be seen as an organic process that evolves with the organization. EA is not static, it changes over time because of changing environments. This can make the EA process complex to describe. In this section the process is described according to a model that has been presented by the META Group (acquired by Gartner in 2005). This model is chosen because of its relative simplicity and procedural approach which makes it easy to follow.

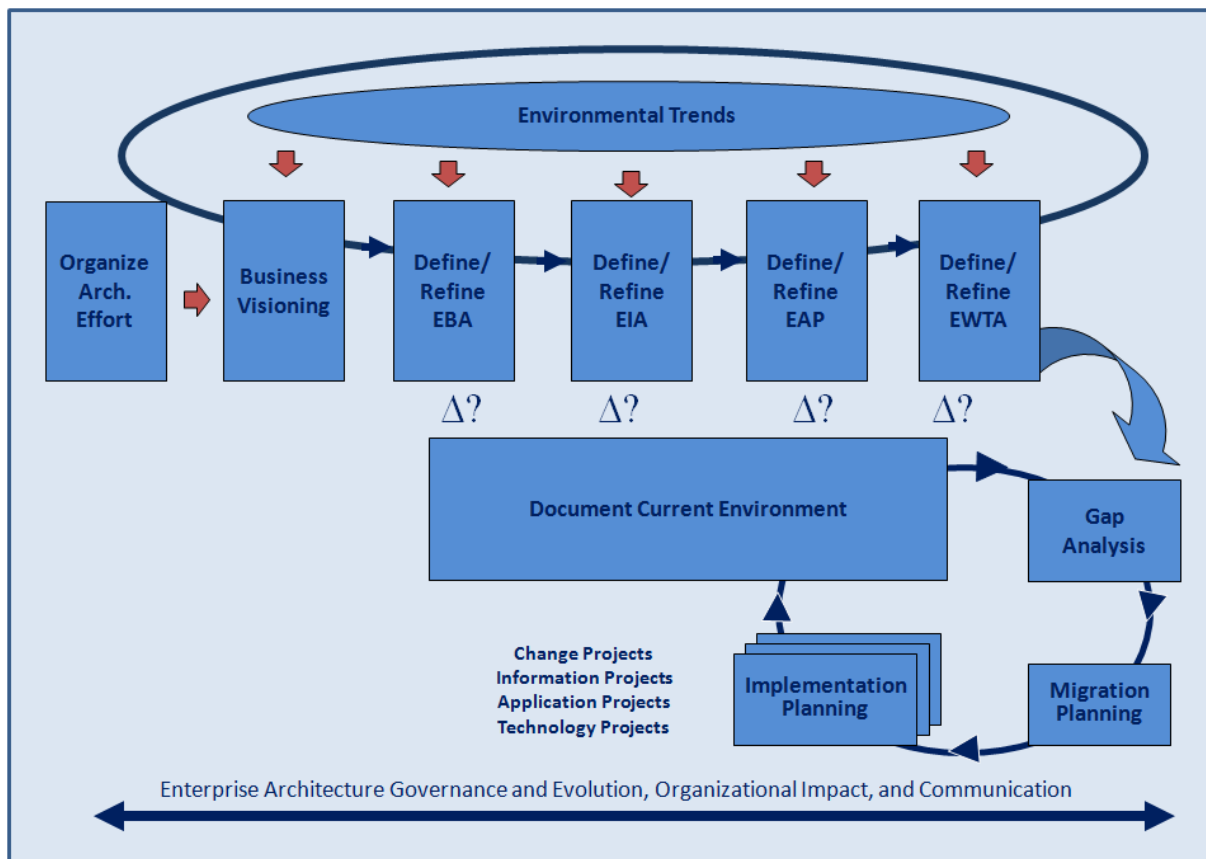


Figure 3.2: Enterprise Architecture Process (Gartner (META Group), 2005)

Figure 3.2 shows the EA process which starts with evaluating *Environmental Trends*. These are the forces from outside the organization such as technological and business trends but also social and political influences. These trends usually motivate an organization to change or improve services and products.

*Organize Architecture Effort* is the first step in the EA development process, it requires commitment and sponsoring to set up an EA process. The *Business Visioning* is about developing vision and strategy; it is the preliminary stage.

In the four succeeding stages *Enterprise Business Architecture* (EBA), *Enterprise Information Architecture* (EIA), *Enterprise Application Portfolio* (EAP) and *Enterprise Wide Technology Architecture* (EWTA) are defined. In these stages the actual architecture work is done and translated into the relevant deliverables. These represent the enterprise's key business, information, application, and technology strategies and their impact on business functions and processes. The four stages are influenced by the Environmental Trends. Changes in principles or in models drive to an analysis of the differences (*Gap Analysis*) between what already exists (the current state) and what will be (the future state).

The *Migration Planning* stage gives a roadmap of all the steps to be done to bridge the gap, whereas *Implementation Planning* is the planning of the actual realization of the solution. At last the new (as-is) state will be documented in the *Document Current Environment* stage.

The result of this model is a *top-down* approach for analyzing and applying change in the enterprise. The forces from outside the organization (Environmental Trends) initiate a demand to redefine the EA process, which then will be applied on a lower level in the organization.

During each step in the EA development process, products are created that together describe the Architecture of the Enterprise. These EA products are the guiding framework that

supports and controls changes in the organization over time. The Dynamic Architecture Maturity Matrix can be used as a tool that determines the status of this EA development process as well as the status of the products which are the result of the various steps in this process.

### **3.5 Maturity of organizations is important for EA success**

EA needs an initial set up. After this initial set up, EA is developed, maintained and applied through an ongoing process. Many steps and activities should be repeated and the deliverables (e.g. documentation) should be updated systematically. By recording and documenting these changes a trend can be identified which shows if an organization is improving its EA. So the EA process can be controlled and quality can be improved.

EA frameworks are used to support organizations in their EA development process. Monitoring of the EA progress, the development of models and blueprints as well as using them to guide implementation programs and projects, can be done by applying Enterprise Architecture Maturity models. Enterprise Architecture Maturity is an important aspect in the field of development and use of EA. There are several Enterprise Architecture Maturity models that can be used to monitor the current state (maturity level), to do a diagnosis and to suggest changes and improvements in organizations. These models are often based on the Capability Maturity Model (CMM), which shows the maturity of an organization according to pre defined levels (in more depth explained in Chapter 4). There is a wide variety in maturity models, some models only show the current EA state in the organization, while others go further and actually give suggestions on how to improve the organization on different aspects. The next chapter will elaborate on these maturity models and will also compare the models with each other explaining differences and similarities. An important aspect of this thesis is the Dynamic Architecture Maturity Model, therefore this model will be further elaborated and compared to the other maturity models.

## 4. Enterprise Architecture Maturity Models

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### 4.1 Introduction

Implementing Enterprise Architecture can have many benefits as described in Chapter 2. Benefits will be different depending on the stakeholder involved. Benefits related to information systems will be found in any stage of the life-cycle of these systems i.e. applications and technical infrastructure. Using architecture frameworks will lead to controlled design of these systems. Costs and efforts related to construction, maintenance, deployment and use will be reduced by uniform guidelines and standardization of building blocks and processes. Flexibility of these systems will increase and lead to shorter time to market of applications, and more business value for these applications by faster access to information. However not every organization will gain benefits at the same level when it implements EA. This depends on the *maturity* of the EA process: which architecture products are defined, how are these used and in which way are architecture efforts organized. Instruments to assess the maturity of the EA process should be part of EA frameworks.

In the previous chapter EA was described from a historical perspective. Its meaning, the definitions and the possible benefits were clarified. This chapter will focus on maturity of the architecture process. Architecture Maturity will be discussed in terms of CMMI, CMMI being a starting point for assessing quality of processes and organizations. An overview of architecture maturity models and matrices available in the market is also given in this chapter.

We will discuss in more depth Dynamic Architecture and more in particular its Dynamic Architecture Maturity Matrix. DyAMM is an instrument used to assess the maturity of the architecture process.

## 4.2 Maturity Modeling: The basis

The concept of maturity in the context of this research originates from the technology sector. Basically maturity and maturity levels are related to the various aspects within a process of product development. Maturity assessment has everything to do with quality management during the process of development and usage of application software and more in general information technology.

### 4.2.1 Quality Management Maturity Grid

One of the first approaches was introduced by Crosby in his Quality Management Maturity Grid (QMMG). He already wrote about this subject in his first book '*Quality is free*' in 1979. The grid is still being used by organizations as a benchmark for assessing how mature their processes are with respect to service and product quality management. QMMG addresses six areas of quality management and each with five maturity stages through which companies evolve. The Grid is presented in figure 4.1 (Crosby, 1979; 1996).

Quality Management Maturity Grid (Crosby)					
Assessor:		Department:			
Measurement Categories	Stage 1: <i>Uncertainty</i>	Stage 2: <i>Awakening</i>	Stage 3: <i>Enlightenment</i>	Stage 4: <i>Wisdom</i>	Stage 5: <i>Certainty</i>
<b>Management understanding and attitude</b>	No comprehension of quality as a management tool. Tend to blame quality department for "quality problems".	Recognising that quality management may be of value but not willing to provide money or time to make it all happen.	While going through quality improvement programme learn more about quality management; becoming supportive and helpful.	Participating. Understand absolutes of quality management. Recognise their personal role in continuing emphasis.	Consider quality management as an essential part of company system.
<b>Quality organisation status</b>	Quality is hidden in manufacturing or engineering departments. Inspection probably not part of organisation. Emphasis on appraisal and sorting.	A stronger quality leader is appointed but main emphasis is still on appraisal and moving the product. Still part of manufacturing or other.	Quality department reports to top management, all appraisal is incorporated and manager has role in management of company.	Quality manager is an officer of company; effective status reporting and preventive action. Involved with customer affairs and special assignments.	Quality manager on board of directors. Prevention is main concern. Quality is a thought leader.
<b>Problem handling</b>	Problems are fought as they occur; no resolution; inadequate definition; lots of yelling and accusations.	Teams are set up to attack major problems. Long-range solutions are not solicited.	Corrective action communication established. Problems are faced openly and resolved in an orderly way.	Problems are identified early in their development. All functions are open to suggestion and improvement.	Except in the most usual cases, problems are prevented.
<b>Cost of quality as % of sales</b>	Reported: Unknown Actual: 20%	Reported: 3% Actual: 18%	Reported: 8% Actual: 12%	Reported: 6.5% Actual: 8%	Reported: 2.5% Actual: 2.5%
<b>Quality improvement actions</b>	No organised activities. No understanding of such activities	Trying obvious "motivational" short-range efforts.	Implementation of a multi-step programme (e.g. Crosby's 14-step) with thorough understanding and establishment of each step.	Continuing the multi-step programme and starting other pro-active / preventive product quality initiatives.	Quality improvement is a normal and continued activity.
<b>Summary of company quality posture</b>	"We don't know why we have problems with quality".	"Is it absolutely necessary to always have problems with quality?"	"Through management commitment and quality improvement we are identifying and resolving our problems."	"Defect prevention is a routine part of our operation."	"We know why we do not have problems with quality."

Figure 4.1: Crosby's Quality Management Maturity Grid (Crosby, 1979)

QMMG has the focus on Quality Management, however this grid is being used in a much wider scope. Many maturity models have been derived directly or indirectly from this grid. The *maturity stages* and *key process areas* have become fundamental building blocks for the current maturity models. A very well known example is the Capability Maturity Model (CMM) for software development. This model is described in the next section.

It is difficult to find a uniform definition and characterization of maturity levels when applied within different environments and situations. So it is inevitable to modify grids and matrices according to the specific process or field of interest. In this thesis maturity must be defined within the particular context of the Enterprise Architecture Process.



#### 4.2.2 Capability Maturity Model (Integration)

In the early 90s the Capability Maturity Model (CMM) was developed by the US Department of Defense and operated by the Software Engineering Institute (SEI) at Carnegie Mellon University. In the EA practice CMM is seen as a basis for EA maturity models. CMM is focused on improving processes in organizations. It provides guidance for developing processes and it describes the improvement path from immature to mature processes through a five level maturity scale. It is important to note that this model shows *what* to do, but not *how* and by *whom* it needs to be done, it is not a process (Bahill, 2009). This model has gained wide acceptance over the last two decades and although its focus was originally on software solutions it grew to multiple IT disciplines. These are mentioned by the Open Group in its architecture framework TOGAF 9:

- IPD-CMM (Integrated Product Development Capability Maturity Model)
- P-CMM (People Capability Maturity Model)
- SA-CMM (Software Acquisition Capability Maturity Model)
- SE-CMM (Systems Engineering Capability Maturity Model)
- SW-CMM (Capability Maturity Model for Software)

Using a combination of different models can cause problems, for example the increase of complexity and redundancy. In 1997 SEI developed CMM Integration in order to integrate and standardize several successful source models (SW-CMM, SE-CMM and IPD-CMM) of CMM (Bahill, 2009; Wikipedia, 2010). Since this model is not specifically focused on software it has a more generalized approach, resulting in a more abstract model than CMM.

CMMI provides benefits for organizations on different aspects. In software and systems engineering CMMI can be used as a tool for benchmarking. Furthermore it helps organizations to examine the effectiveness of their processes and to prioritize the improvements. CMMI is not prescriptive, but it helps implementing improvements by acting as a roadmap (Bahill, 2009; Godfrey, 2008).

Several versions of CMMI have been published since 1997, version 1.3 has been published in 2010 and is the most recent. Figure 4.2 shows the original CMMI model and visualizes the maturity levels. These levels are generic and thus applicable to all variants of the CMMI models (CMMI for Development, CMMI for Services, CMMI for Acquisition). The CMMI model is used as a basis for other maturity models. The clear structure makes it relative easy to apply this model on different subjects in the (Information) Technology sector.

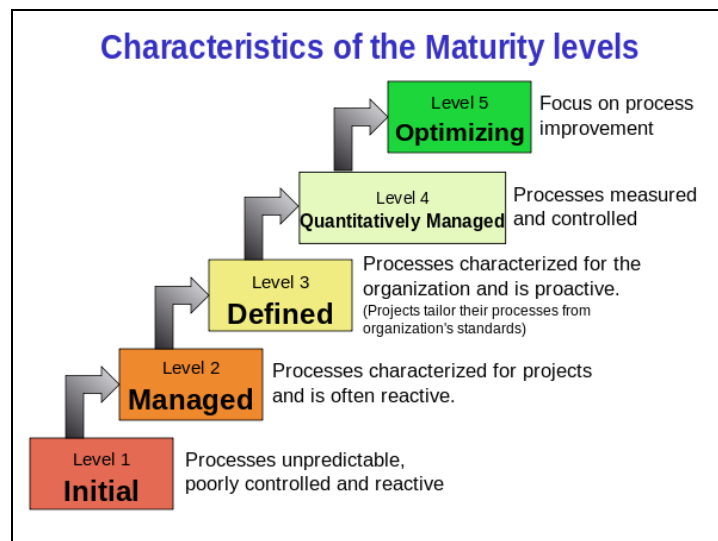


Figure 4.2: Capability Maturity Model Integration, the five levels of maturity (Godfrey, 2008)

### **4.2.3 Architecture Maturity**

CMMI can be positioned as the base model for determining and evaluating the quality of processes and organizations from the perspective of development and use of information systems. This model is used as a tool to measure and assess the state of maturity of an organization, it also provides the organization with a roadmap for improvement steps.

In particular the EA process and the activity of assessing EA process maturity can be mapped onto CMMI. CMMI levels and CMMI terminology can be interpreted and translated into terms of EA process maturity. Many organizations have developed their own EA maturity models which are based upon CMMI.

However, this research will not be focused on CMMI. More specifically the focus will be on DyAMM, and to a lesser extent on other EA maturity models that are relevant in relation to DyAMM.

Section 4.3 will start with a discussion on Sogeti's method DyAMM being the core of this research. Other relevant examples of maturity models will be discussed in section 4.4 in order to provide an insight in the similarities and differences between maturity models.

## **4.3 Dynamic Architecture (DyA)**

The Dynamic Architecture Maturity Matrix (DyAMM) is part of the Dynamic Architecture (DyA) method. In order to better understand the working of this maturity matrix, the basic principles of the DyA method will be described in this section. For further in-depth reading, the DyA-books and website are recommended (Van den Berg & Van Steenberg, 2006; Van Steenberg, Van den Berg, & Brinkkemper, 2007b). In this research the focus lies on describing the DyA Maturity Matrix and the DyA Maturity Assessment method in such a way that it is understandable for the reader within the context of this research.

### **4.3.1 Introduction**

From 1998 several architects from Sogeti began to develop a new EA method. The method is based on years of practical experience of the authors in their field of profession. In April 2001 the first version of DyA was finally published. This version contained several instruments (including the maturity matrix) for architects to work more effectively with Enterprise Architecture. In 2005 a new version of DyA was developed to replace the previous version. This version was also published as a new book in 2006. This updated version is nowadays in use and is also the basis for this thesis. Since the publication of the first version, DyA has become more popular within organizations and has been frequently discussed during conferences and seminars. This has also led to more awareness of the method within the architecture community. During the last years DyA is applied more and more by organizations mainly on the Dutch market but also in several organizations abroad.

### **4.3.2 The DyA model**

DyA is an EA method that describes the vision on the development and maintenance of architecture through a dynamic approach. It does not only involve the production of architecture but more importantly it addresses the embedding of architecture in the organization. DyA is founded on the following basic principles:



- “The architecture process is as important as the architecture products. It is no use developing perfect architectural products if no attention is being paid to the embedding of these products in the organization.
- *Architecture facilitates change.* Architecture is a management instrument intended to give direction to the changes that are continuously taking place in an organization.
- *Just enough, just in time architecture.* The development of architecture must be driven by business needs.
- *Deviations from the architecture are allowed, but in a controlled way.* A process must be implemented of managing justified deviations from the architecture.”

Figure 4.3: DyA principles (Van den Berg & Van Steenberg, 2006)

The principles listed above recur clearly in the DyA model. This model plays a central role in the DyA method. Figure 4.4 shows the relations and processes within the model. The model shows three main parts: *DyA processes*, *Dynamic Architecture* and *Governance*.

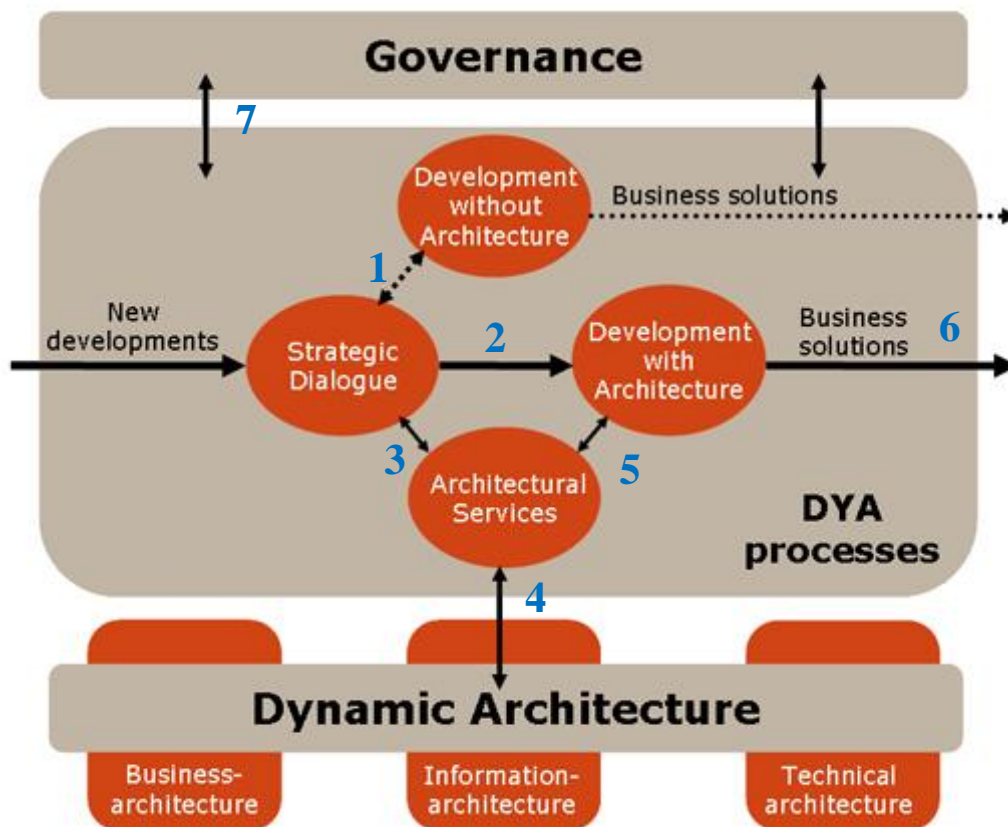


Figure 4.4: DyA Model (Van den Berg & Van Steenberg, 2006)

The component *DyA processes* consists of four processes which cover the entire process of change ranging from strategy formation to realization.

- *Strategic dialogue:* The business objectives are defined in the strategic dialogue. In modern businesses IT is of strategic importance. Therefore alignment between business and IT management is important.
- *Architectural services:* The architectural services are positioned as a supportive process. It defines and manages the architecture, it is an enabler to guide changes in order to achieve

the business objectives. It functions as a bridge between the business objectives and the project responsible for the solutions.

- *Development with architecture*: Achieving the concrete business objectives. This is done within the desired time frame and in accordance with the anticipated quality and costs. Developing with architecture is the default.
- *Development without architecture*: Deviate from the architectural framework. In some cases it can be necessary to design without architecture, for example when there is extreme time pressure.

The *strategic dialogue* is the process of developing new ideas and creating business goals, during this process initial decisions are made with regard to *development with and without architecture*. In case of an ad-hoc solution it is possible to choose for *development without architecture*, shown with a dotted line (1). Usually in more complex situations a *development with architecture* is recommended, shown with a horizontal arrow (2). The *strategic dialogue* initiates the process for *architectural services*, shown by arrow (3). In *architectural services* the architectures, represented in the component *Dynamic Architecture*, are formulated to support the strategic dialogue and interact with *development with architecture* (5).

The component *Dynamic Architecture* contains on the one side architecture defined as a product, and on the other side it contains the process of architecture, the way architecture is being dealt with. This is done for business, information and technical architectures.

The component *DyA processes* is connected with both *Governance* (7) and *Dynamic Architecture* (4). It plays a central role in supporting the corporate *Governance* process by translating the *Dynamic Architecture* into usable input for guidance in meeting the business goals. DyA is being used as a tool to support the *Governance* process. It is intended to be an instrument to support (corporate) management. The final output is a solid business solution (6), based on a carefully considered architecture plan.

### 4.3.3 The Dynamic Architecture Maturity Matrix (DyAMM)

The DyA method contains a number of instruments. An important instrument of the DyA method is the Architecture Maturity Matrix. The Dynamic Architecture Maturity Matrix (DyAMM) is used as an EA maturity assessment tool. The input for this maturity matrix is delivered by maturity assessments containing questions relevant to EA maturity.

#### 4.3.3.1 Meaning of the maturity matrix

The maturity matrix supports two goals. On the one hand the maturity matrix is meant to assess the state of the enterprise architecture (process) within an organization. This matrix will determine the state of quality for the different aspects of an enterprise architecture. On the other hand the matrix will support in identifying and prioritizing possible improvements, based upon the outcome of the assessment. So the instrument is not only meant to ‘measure’ the current state, but also meant to support and guide an organization to actually improve the architecture process.

It is important to emphasize that the maturity *matrix* is different from other maturity *models*, apart from the aspect of improvement and prioritization. In most cases the classic maturity models contain ‘only’ five separate maturity levels, whereas this maturity matrix has a more detailed approach.

The format of the DyAMM was inspired by the Test Process Improvement (TPI) Model (Koomen & Pol, 1999). The first version of the DyAMM (version 1.0) was developed in 2002 by a group of experts on the basis of many years of practical experience in the field of enterprise architecture. After several applications of the DyAMM, in 2004 a revised version

(version 1.1) was published. It mainly consisted of a repositioning of maturity levels. This version has been qualitatively validated by applying it to several cases (Van Steenberg, Van den Berg, & Brinkkemper, 2007b).

#### 4.3.3.2 The key components of the maturity matrix

DyAMM basically uses three key components to analyze the state of maturity. In figure 4.5 these three components are encircled and numbered.

A list of focus areas was defined to cover 18 aspects of EAM: the *key-areas* (2). Maturity levels are defined for each individual key area: the *maturity levels* (3). The third component is located on the horizontal axis which reflect the overall maturity of an organization, the (maturity) *scale* (1). Each of these components is described in more detail below.

Key Areas	Scale	0	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Development of Architecture			A			B			C						
2 Use of Architecture				A			B				C				
3 Alignment with business			A				B				C				
4 Alignment with the development process				A				B		C					
5 Alignment with operations						A			B			C			
6 Relationship to as-is state						A				B					
7 Roles and responsibilities					A		B					C			
8 Coordination of developments								A			B				
9 Monitoring					A		B		C		D				
10 Quality management									A		B			C	
11 Maintenance of the architectural process								A		B		C			
12 Maintenance of architectural deliverables						A			B					C	
13 Commitment and motivation			A					B		C					
14 Architectural roles and training					A		B			C			D		
15 Use of an architectural method					A						B				C
16 Consultation				A		B				C					
17 Architectural tools							A					B			C
18 Budgeting and planning					A							B		C	

Figure 4.5: Sogeti – Dynamic Architecture Maturity Matrix (Van den Berg, & Van Steenberg, 2006)

For a better explanation of the maturity matrix, component two (2) and three (3) are described before component one (1). In section 4.4.2, which describes several other maturity models, we follow the normal sequence of first describing component one, then two and three. This makes it easier to compare the maturity models later on in section 4.5.

#### Key areas (2)

The Maturity Matrix has a list of 18 key areas. Each key area is focused on a specific topic or subject that is relevant for the Enterprise Architecture practice. In table 4.1 the full list of 18 key areas is given with their definitions.

Key area	Definition
Development of architecture	The approach to architecture development, varying from isolated, autonomous projects to an interactive process of continuous facilitation.
Use of architecture	The way architecture is used: merely as a conduit for information, as a means of governing individual projects or even as a tool for managing the entire organization.
Alignment with business	The extent to which the architectural processes and deliverables are in tune with what the business wants and is capable of.
Alignment with the development process	The extent to which architecture is embedded in the existing (business and IT) development processes of the organization.
Alignment with operations	The extent to which architecture is both used in and built on the operations and maintenance discipline.
Relationship to the as-is state	The extent to which the existing situation is taken into account by the architecture processes and deliverables.
Roles and responsibilities	The distribution of responsibilities concerning both architecture processes and deliverables within the organization.
Coordination of developments	The extent to which architecture is used as a steering instrument to coordinate the content of the many developments that usually take place concurrently.
Monitoring	The extent to which and the manner in which compliance of projects with the architecture is guaranteed.
Quality management	The extent to which quality management is applied to the architecture practice.
Maintenance of the architectural process	The extent to which the architectural process is actively maintained and improved.
Maintenance of architectural deliverables	The extent to which and the manner in which the architectural deliverables are kept up to date.
Commitment and motivation	The extent to which commitment is attained from and shown by the organization.
Architectural roles and training	The acknowledgement and support of the architectural roles and the extent to which architects can educate themselves.
Use of an architectural method	The extent to which a (common) architectural method is used.
Consultation	The extent to which communication among architects and between architects and their stakeholders takes place on a structural basis.
Architectural tools	The extent to which architects are supported by tools.
Budgeting and planning	The extent to which architectural activities are budgeted and planned.

**Table 4.1: Key areas with description (Van Steenberg, Schipper, Bos & Brinkkemper, 2009)**

### Maturity levels (3)

Each key area has a number of possible maturity levels. The characters in the cells represent these possible levels of maturity for each key area. The number of possible maturity levels may differ for each key area, varying from two to four levels. This means that some key areas have two maturity levels (e.g. Relation to the as-is state), while others have three or even four maturity levels (e.g. Monitoring). In total the matrix contains 54 characters, each reflecting a certain maturity level corresponding to a key area. Each maturity level (character) is covered by one or more of the 137 assessment questions, the so called checkpoints.

For *each individual key area* the maturity levels should always be achieved in a fixed order: first level A then B, and if applicable level C and D. Although this order is always fixed, the *time* at which a certain maturity level should be met, is determined by the position of the characters. These positions reflect the prioritization that is given in the maturity matrix for the individual key areas. For example the key area *development of architecture* has level A positioned at Scale 1. The key area *architectural tools* has level A positioned at Scale 6. This means that level A for *development of architecture* should be reached before level A of the

key area *architectural tools*. This is because, according to DyAMM, certain key areas should be developed first and reach a certain maturity, before other key areas should get their attention.

#### Maturity scale (1)

On the upper horizontal axis the 14 columns define the progressive overall maturity scale, value 0 being the lowest and value 13 being the highest achievable. An organization has reached the overall maturity level  $l$  ( $0 \leq l \leq 13$ ) if:

- 1) all key area maturity levels in the column  $l$  have been reached *and*
- 2) all key area maturity levels left to column  $l$  have been reached *and*
- 3) *not* all key area maturity levels to the right of column  $l$  have been reached.

Thus, for an organization to be at maturity scale 1, it must have achieved the first maturity levels (A) of the key areas *Development of architecture*, *Alignment with business* and *Commitment and motivation* (the A's in column 1) and not all of the key area maturity levels to the right of column 1. To get to scale 2, additionally the first maturity levels of the key areas *Use of architecture*, *Alignment with the development process* and *Consultation* have to be achieved (the A's in column 2). And so on. Once all characters in columns 1 to 3 have been achieved, it is time to develop all key areas that are prioritized in column 4 to the next level: *Development of architecture*, *Alignment with operations*, *Relation to the as-is state*, *Maintenance of the architectural deliverables* and *Consultation*. In this way the matrix can be used to set priorities in developing the architectural practice.

#### 4.3.4 Using the maturity matrix

The DyA maturity assessment acts as an input to the maturity matrix. The assessment contains a questionnaire with questions corresponding to all 18 key areas. The result of this questionnaire is projected into the maturity matrix, showing the scores for each key area.

Key Areas \ Scale	0	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Development of Architecture		A			B			C						
2 Use of architecture			A			B				C				
3 Alignment with business		A				B				C				
4 Alignment with the development process			A				B		C					
5 Alignment with operations					A			B			C			
6 Relationship to as-is state					A				B					
7 Roles and responsibilities				A		B					C			
8 Coordination of developments							A			B				
9 Monitoring				A		B		C		D				
10 Quality management								A		B			C	
11 Maintenance of the architectural process							A		B		C			
12 Maintenance of architectural deliverables					A			B					C	
13 Commitment and motivation		A					B		C					
14 Architectural roles and training				A		B			C			D		
15 Use of an architectural method				A						B				C
16 Consultation			A		B				C					
17 Architectural tools							A				B			C
18 Budgeting and planning				A							B		C	

Figure 4.6: Example of a filled in maturity matrix based on the results of a DyA maturity assessment.



Figure 4.6 shows an example of a filled in maturity matrix based on a DyA maturity assessment (questionnaire) executed within an organization. The organization depicted shows an unbalance, some key areas like *Alignment with the development process*, are quite far developed, while others, like *Use of architecture* are not yet developed at all. Despite the relatively high development of some of the key areas, on the whole the organization in figure 4.6 has only reached scale 1. This is clarified by looking at the red circle. The key area *Use of architecture* has not reached level A, thus blocking the progress to scale 2.

## 4.4 Overview of EA Maturity Models

Since the beginning of maturity modeling in general, at least 150 maturity models have been developed each with their own characteristics and broad in application (Bruin et al, 2005). The last decade has produced several different EA maturity models which often have a different focus, but nevertheless they have a lot in common. Both the Quality Management Maturity Grid and later CMMI, set a standard for maturity modeling with regard to the structure of the models. They show maturity levels and/or stages that are still being used in the more recent EA maturity models.

Although a reasonable amount of scientific research is being done with regard to EA, the dimension of developing a maturity model is underexposed in the academic world. There are some research institutes (e.g. Gartner, MIT) that have developed a kind of EA maturity model, but documentation is still very limited. The public sector, especially the US government, has pushed the development of maturity models forward, however as described in section 3.2 it is heavily driven by legislation and government rules. There are numerous organizations such as consultancy firms that develop maturity models, but only few manage to deliver a maturity model that is complete and well documented.

In the next sections an overview of the most known and actively used models is given. Additionally a few maturity models are highlighted and compared with the previously described DyAMM. This will give a perception of how DyAMM compares to other maturity models.

### 4.4.1 Common EA maturity models

After reading literature, consulting online sources and talking to enterprise architects a list of EA maturity models was created. This list contains the EA maturity models that are generally used and accepted by the EA community. Of course even more maturity models for EA are known (ISO-Architecture, 2011). However these models are often not ‘complete’, not well documented and they often lack an EA focus in their approach. The final list contains six EA maturity models. These models are well supported and referred to in literature (on the Internet and in books) and are widely applied in real life cases. Although the maturity models show a high degree of resemblance with other generic models, there are differences. Both the resemblances and differences will be further elaborated in this chapter.

Publications are available that describe these differences between maturity models on a detailed level through a classification system (Mettler, Rohner & Winter, 2010). A study on comparison of different maturity models has been made in 2009 using the classification system of Mettler (Szyszka, 2009). The study also describes a classification according to Van Steenberg et al. (2007a) which categorizes maturity models into three categories. The three categories are described in figure 4.7. Focus areas can also be read as key (performance) areas. Table 4.2 presents this classification along with some additional properties of the maturity models. The classification was updated in 2011 (Van Steenberg, 2011) with a more detailed definition.

- “*Staged fixed-level models*. Staged fixed-level models distinguish a fixed number of generic levels of maturity, usually around five. Each maturity level contains a number of focus areas that have to be implemented for the organization to achieve that particular level. The best-known staged fixed-level maturity model is the Capability Maturity Model for Software (CMM) and its successors (Paulk et al. 1993).
- *Continuous fixed-level models*. Continuous fixed-level models also distinguish a fixed number of generic maturity levels. They differ from the staged fixed-level models in the fact that in the continuous models, focus areas are not attributed to a level, but the generic maturity levels are distinguished within each focus area. The Capability Maturity Model Integration (CMMI), which is developed to solve the problem of applying various capability maturity models by providing a single improvement framework, distinguishes both a staged and a continuous representation (CMMI, 2002)
- *Focus area models*. Focus area models do not distinguish a fixed number of generic maturity levels, but instead define specific maturity levels for each focus area. The overall maturity of an organization is expressed as a combination of the specific maturity levels. Focus area models are much less common than fixed-level models. Examples are the Test Process Improvement (TPI) model developed by Koomen and Pol (1999) and the models for enterprise architecture and software product management studied in this paper.”

**Figure 4.7: Classification of maturity models (Van Steenberg, Van den Berg, Brinkkemper, 2007a; Van Steenberg, 2011)**

In table 4.2 the relevant models are listed showing some of their properties. From left to right: The column *Organizational* shows the name of the model, the institute that developed the model and the sector of the organization that developed the model (public or private). The column *Model structure* shows the model type (staged, continuous, focus), the number of identified maturity stages and the number of identified key areas. The last column *version history* shows the initial year of development and the recent version of the model that is used in this research.

#### *Selection of the maturity models*

The intention is to make a selection of maturity models that are ‘complete’, well documented and generally used by the EA community. This research is aimed at DyAMM, therefore DyAMM will be the basis for comparison of the models. Based on the classification of Steenberg et al. (2007a), one maturity model is chosen from each of the three categories: *staged*, *continuous* and *focus area*. This results in a comparison of three models. The classification is used to assure some fundamental differences between the compared models. The categories *staged* and *focus area* both contain only one model, respectively GAO/EAMMF and Sogeti/DyAMM. The category *continuous* contains four models. Both OMB/EAAF and DoC/EACMM are fully developed by the U.S. government for a specific department. From this category NASCIO/EAMM is chosen as the third model, because it is more generic and not dedicated to one department. It has been developed in cooperation with the CIO’s from different states in the United States. The official documentation with regard to IFEAD/E2AMM is poor, it contains four pages with a minimal description of the model and lacks further explanation of all the elements. The application of E2AMM in businesses is very limited and almost no real life examples exist. Further the organization behind this model is relatively young compared to that of NASCIO. NASCIO has a better track record with regard to its history of development and the application of its maturity model in organizations.

DyAMM has been extensively described in section 4.3 of this chapter. The two remaining models are described in the next sections. The models will be compared on their fundamental building blocks and properties.

Organizational			Model structure			Version history		
Model	Institute (Full model name)	Sector (Public, Private)	Type (Staged, Continuous, Focus)	Maturity Stages	Key areas	Initial	Current (Used in this research)	
GAO/EAMMF	U.S. Governance Accountability Office (EA Management Maturity Framework)	Public	Staged	7	4 (15 sub)*	2002	2010	2.0
OMB/EAAF	U.S. Office of Management and Budget ( EA Assessment Framework)	Public	Continuous	5	12	2002	2009	3.1
DoC/EACMM	U.S. Department of Commerce (Enterprise Architecture Capability Maturity Model)	Public	Continuous	6	9	2001	2007	1.2
NASCIO/EAMM	National Association of State Chief Information officers (Enterprise Architecture Maturity Model)	Public	Continuous	6	8	2001	2003	1.3
IFEAD/E2AMM	Institute for Enterprise Architecture Developments ( Extended Enterprise Architecture Maturity Model)	Private	Continuous	6	11	2003	2006	2.0
Sogeti/DyAMM	Sogeti (Dynamic Architecture Maturity Matrix)	Private	Focus	14	18	2001	2006	1.1

**Table 4.2: List of EA maturity models with their distinctive properties**

**Sources:** U.S. Governance Accountability Office (GAO) (2010a),  
U.S. Office of Management and Budget (OMB) (2010),  
U. S. Department of Commerce (2007),  
National Association of State Chief Information Officers (NASCIO) (2003),  
Schekkerman, (IFEAD) (2006),  
Van den Berg & Van Steenberg (2006),  
Fountain (2004).

\* GAO/EAMMF contains four main key areas. Each key area has several performance indicators, together 15 sub categories.



## 4.4.2 Selection of maturity models

### 4.4.2.1 U.S. Governance Accountability Office (GAO): EA Management Maturity Framework

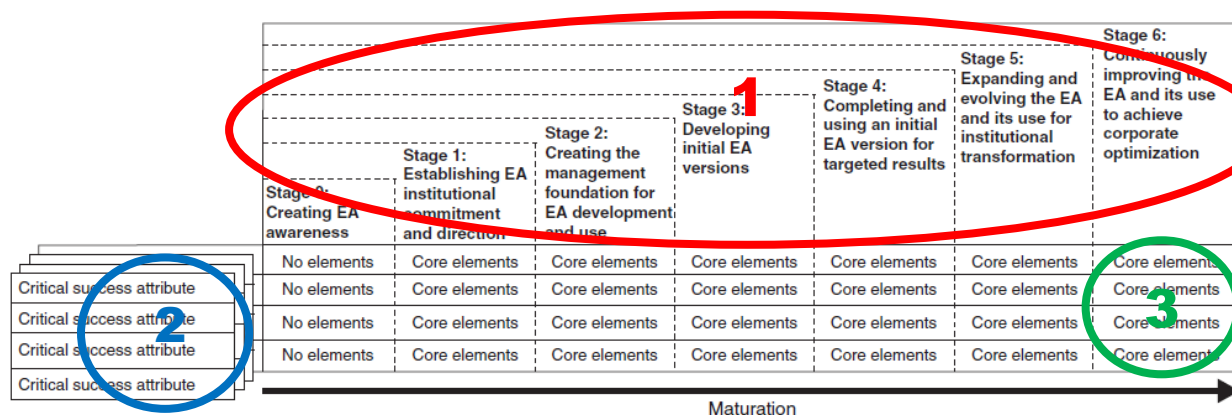
The U.S. Governance Accountability Office (GAO) is an independent institute working for the US Congress, GAO is also referred to as the “congressional watchdog”. In essence the GAO supports the Congress in meeting its constitutional responsibilities by improving performance, ensuring accountability and investigating how tax money is spent.

The EA Management Maturity Framework (EAMMF) has been in development for quite some while. The first version was published in 2002, an updated version was published in 2003. The most current version has been released in 2010, version 2.0 which is a major revision of the previous version. Compared to the previous version, version 2.0 is an expansion of all three components that are described below (Maturity stages, Critical success attributes and Core elements). One striking difference is the addition of two maturity stages, instead of 5 it now has 7 maturity stages.

(U.S. Governance Accountability Office (GAO), 2010a)

#### The model

In figure 4.8 three components are marked with colored ovals. The first (1) component is a hierarchical structure of seven management *maturity stages* ranging from 0 to 6. The second (2) component shows the *Critical success attributes*. The third (3) component consists of 59 *Core elements* that are used as building blocks for EA management.



**Figure 4.8: GAO - EA Management Maturity Framework (U.S. Governance Accountability Office (GAO), (2010a)**

#### Maturity Stages (1)

Each *maturity stage* represents the EA (management) conditions that are described in their corresponding *Core elements*. A certain maturity stage can only be reached if all other previous stages have been fulfilled. The stages function as a road map for an organization that increases its maturity on EA. The seven maturity stages range from no maturity at all (Stage 0) to a maximum maturity (Stage 6) which is focused on quality improvement of the current EA. The stages are shown in table 4.3.

Stage		Short description
0	Creating EA Awareness	There are no plans to develop and use an EA or the plans do not show EA awareness. Organizations may have initiated some EA activity, but their efforts are largely ad hoc and unstructured.
1	Establishing EA Institutional Commitment and Direction	EA development and compliance are grounded into the organizations policy and recognized as a corporate asset by making the executive committee responsible. EA leadership is demonstrated through an institutional commitment to developing and using the EA and a strategic basis for directing its development, maintenance, and use.
2	Creating the Management Foundation for EA Development and Use	The organization establishes operational EA program offices, including a corporate program office that is headed by the chief architect, who reports to the executive committee. Core plans and processes are developed to manage and execute the EA program.
3	Developing Initial EA Versions	Execute EA management plans to deliver an initial version (not ready for implementation) of the architecture that includes current “as-is” and target “to-be” views, as well as an initial version of a plan for transitioning from the “as-is” to the “to-be” views.
4	Completing and Using an Initial EA Version for Targeted Results	Developed a version of its corporate EA that has been approved by the executive committee, to include “as-is” and “to-be” views, as well as an initial version of a plan for transitioning from the “as-is” to the “to-be” views. A range of factors are measured and reported to the executive committee.
5	Expanding and Evolving the EA and Its Use for Institutional Transformation	EA’s scope is extended to the entire organization. The architecture products are governed by a common EA framework, methodology, and repository, thus permitting the products to be appropriately integrated and continuously updated.
6	Continuously Improving the EA and Its Use to Achieve Corporate Optimization	The focus is on continuously improving the quality of EA products and the people, processes, and tools used to govern their development, maintenance and use. An enterprise wide blueprint has been fully established.

**Table 4.3: Maturity stages EAMMF (U.S. Governance Accountability Office (GAO), (2010a))**

#### Critical success attributes (2)

Figure 4.8 shows four layers of critical success attributes, referred to as *representations*. These four representations – Management Action, Functional Area, Capability Area and Enabler – have their own specific critical success attributes with their own specific characteristics. The four representations with their underlying critical success attributes are shown in table 4.4.

Representations		Critical success attributes	
1	EA Management Action Representation	1	Demonstrates commitment
		2	Provides capability to meet commitment
		3	Demonstrates satisfaction of commitment
		4	Verifies satisfaction of commitment
2	EA Functional Area Representation	1	Governance
		2	Content
		3	Use
		4	Measurement
3	Office of Management & Budget Capability Area Representation	1	Completion
		2	Use
		3	Results
4	EA Enabler Representation	1	Leadership
		2	People
		3	Processes
		4	Tools

**Table 4.4: Representations of the Critical success attributes (GAO, 2010a)**

### Core Elements (3)

The 59 core elements are distributed over the maturity stages, except for Stage 0, which has no core elements allocated. The reason is that stage 0 merely represents the phase of making an organization EA aware and the EA activity is mainly ad hoc and unstructured.

The core elements represent the EA practices, structures, activities and conditions (GAO, 2010). If they are performed or met properly, an organization is able to advance to a higher maturity state. Figure 4.9 is an example of how *Maturity Stages*, *Critical success attributes* and *Core Elements* are positioned in the maturity model.

	Stage 0: Creating EA awareness	Stage 1: Establishing EA institutional commitment and direction	Stage 2: Creating the management foundation for EA development and use	Stage 3: Developing initial EA versions	Stage 4: Completing and using an initial EA version for targeted results	Stage 5: Expanding and evolving the EA and its use for institutional transformation	Stage 6: Continuously improving the EA and its use to achieve corporate optimization
<b>Attribute 1: Demonstrates commitment</b>		(1) Written and approved organization policy exists for EA development, maintenance, and use.  (2) Executive committee representing the enterprise exists and is responsible and accountable for EA.  (3) Executive committee is taking proactive steps to address EA cultural barriers.	(9) EA budgetary needs are justified and funded.	(19) Organization business owner and CXO representatives are actively engaged in architecture development.	(33) Executive committee has approved the initial version of corporate EA.  (34) Key stakeholders have approved the current version of subordinate architectures.  (35) EA is integral to the execution of other institutional management disciplines.	(44) Organization head has approved current version of the corporate EA.  (45) Organization component heads or segment owners have approved current version of their respective subordinate architectures.	(53) EA is used by executive leadership to inform organization strategic planning and policy formulation.

**Figure 4.9: An example of the Representation of the Critical Success Attributes and the Core Elements. In this figure the *EA Management Action Representation* is shown with the critical success attribute *Demonstrates commitment* and its corresponding core elements. Core elements are numbered from 1 to 59.**

#### 4.4.2.2 National Association of State Chief Information Officers: Enterprise Architecture Maturity Model

The National Association for State Information Systems (NASIS) was founded in 1969. The organization changed its strategy and name several times. In 2001 it changed its name to the National Association of State Chief Information Officers (NASCIO) which better represents its current activities. It now represents the state Chief Information Officers from 50 states, six U.S. territories and the District of Columbia.

NASCIO developed version 1.3 of the Enterprise Architecture Maturity Model (EAMM) in 2003. The NASCIO EAMM is based on the Capability Maturity Model (CMMI). The model has been developed in order to supply a benchmark tool that can measure the effectiveness of an Enterprise Architecture program. The model also gives an impression of the natural progression of benefits that a supported and managed architecture program will contribute to an organization as it matures. (National Association of State Chief Information Officers (NASCIO), 2003; 2010)

##### The model

Figure 4.10 shows the EAMM with its components. It describes six maturity levels (1), ranging from level 0 to level 5. On the left the second component (2) is shown, it contains eight 'focus areas' related to EA. Component three (3) shows the statements that are related to each EA category. The 'continuous' character of this model is symbolized by the horizontal dotted lines, while the vertical lines symbolize the staged character.

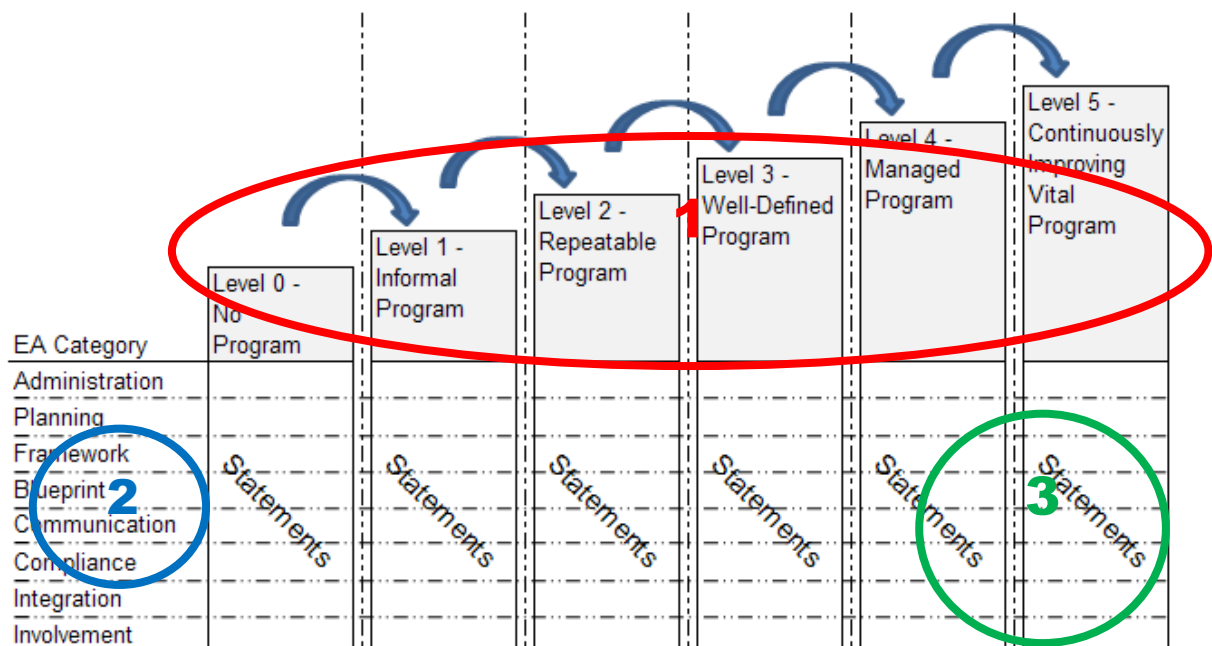


Figure 4.10: NASCIO - Enterprise Architecture Maturity Model (Fountain, 2004)

##### Maturity levels (1)

The *maturity levels* range from no documented EA (level 0) to a mature EA (level 5) with ongoing refinements and improvements. Each level contains the statements that are relevant for that particular maturity level. A certain maturity level can only be reached if all other previous levels have been fulfilled, including the statements that belong to these levels. Since EAMM is based on the original CMM developed by SEI, the levels in both models are quite similar. Instead of the usual 5-level model, this model has six levels. EAMM has created an

extra level 0, which clearly describes a situation with a non existing EA program. An overview of all six levels is shown in table 4.5.

Level	Description
0	No program
1	Informal program
2	Repeatable program
3	Well-defined program
4	Managed program
5	Continuously improving vital program

**Table 4.5: Maturity levels EAMM (NASCIO, 2003)**

### EA categories (2)

Figure 4.10 shows eight Enterprise Architecture categories. The categories are projected on all six maturity levels, the categories are shown below in Table 4.6. Each category contains statements (explained in the next section) that are distributed over the six maturity levels. In other words, a maturity level contains several statements from all eight EA categories.

Category	Description
1	Administration
2	Planning
3	Framework
4	Blueprint
5	Communication
6	Compliance
7	Integration
8	Involvement

**Table 4.6: EA categories EAMM (NASCIO, 2003)**

### Statements (3)

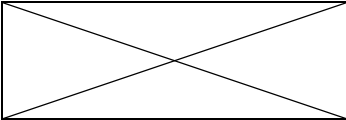
The EA categories described above contain in total 108 statements. A statement is an indicator for an EA program at a certain level. An example of a statement for level 2 for the category planning is: *'The organization has begun to develop a vision for Enterprise Architecture'*. Each maturity level contains one or more statements for each of the eight

categories, the statements together give a picture of the EA program for an organization at that level. In order to progress to the next maturity level (n), all statements of all eight categories with respect to last maturity level (n-1) need to be met.

## 4.5 DyAMM, GAO and NASCIO compared

In this chapter three maturity models have been described extensively. The models have several aspects in common, but they also have some clear differences. This section shows an overview of the most important similarities and differences between the maturity models that were compared.

The Quality Management Maturity Grid (QMMG) can be seen as the predecessor of many maturity models. It shows a grid or matrix structure that many current maturity models are still using. Each maturity model discussed in this chapter consists of several components that are similar to each other. DyAMM, GAO and NASCIO all consist of maturity levels, EA categories and statements. These are in essence very similar to each other and therefore are easily translated into a maturity grid. They mainly differ in how detailed components are visualized and described. Figure 4.11 shows the basic structure of a generic maturity grid. The colored numbers one, two and three correspond with the numbers in the previous figures; figure 4.5 (DyAMM), figure 4.8 (GAO) and figure 4.10 (NASCIO).

	<b><u>Maturity levels</u></b> <ul style="list-style-type: none"> <li>▪ Number of levels</li> <li>▪ Detail of Level description</li> </ul> <div style="text-align: right; border: 2px solid red; border-radius: 50%; width: 40px; height: 40px; display: flex; align-items: center; justify-content: center; margin: 0 auto;">1</div>
	<b><u>Statements</u></b> <ul style="list-style-type: none"> <li>▪ Number of statements</li> <li>▪ Detail of Statement description</li> </ul> <div style="text-align: right; border: 2px solid green; border-radius: 50%; width: 40px; height: 40px; display: flex; align-items: center; justify-content: center; margin: 0 auto;">3</div>
<b><u>EA categories</u></b> <ul style="list-style-type: none"> <li>▪ Number of categories</li> <li>▪ Detail of Category description</li> </ul> <div style="text-align: right; border: 2px solid blue; border-radius: 50%; width: 40px; height: 40px; display: flex; align-items: center; justify-content: center; margin: 0 auto;">2</div>	

**Figure 4.11: A generic maturity grid – Three components. Differences in numbers of items and description details.**

### Similarities and differences

The three components - maturity levels, EA categories and statements - are shown in one grid. DyAMM, GAO and NASCIO all consist of similar components. Differences can especially be seen in the *number* of levels, categories and statements; and the *detail* in which they are described.

### Maturity levels

While GAO has seven and NASCIO has six maturity levels, DyAMM has twice as much as GAO, in total 14 maturity (*scale*) levels. GAO and NASCIO explicitly define the meaning of their maturity levels, giving a description for each individual maturity level. DyAMM defines their maturity levels by using a progressive scale which shows the overall maturity level, ranging from a low score (0) to a maximum score (13) being very mature. So DyAMM does not give an explanation of the state of each individual maturity level, which is a weak point.

### EA categories

The use of EA categories are different for each of the models in both, numbers and structure. DyAMM, NASCIO and GAO have respectively 18, eight and four EA categories. GAO uses



only four categories, but also differs in structure by adding 15 additional sub categories (See table 4.4). The sub categories are used as performance indicators, which combined together support the main categories. DyAMM covers by far the most aspects with regard to EA categories. By using a relatively large number of categories (with a broader scope on EA), DyAMM provides a more detailed tool for pinpointing possible problem areas that should get more attention. The EA categories are similar with those of NASCIO, but are specified in more detail.

### Statements

With regard to the statements there are more differences between the models.

NASCIO has 109 statements divided over the six maturity levels. By passing all statements of all eight categories that are assigned to the same maturity level an organization can progress to higher maturity level. The statements are short and are not further supported by a description or examples.

GAO uses a similar approach by assigning the statements - in this case they are called 'core elements' - to each of the seven maturity levels. The 59 core elements are divided over all critical success attributes (the 15 sub categories, previously described in section 4.4.2.1). The 59 core elements are described in much more detail compared to NASCIO. The core elements are supported by an extensive description based on examples.

DyAMM has an additional aspect of maturity. The statements or in this case the 137 questions, are divided over the 18 EA categories. Additionally to NASCIO and GAO it uses an extra maturity range for individual EA categories (previous explained in section 4.3.3.2). EA categories score independently from each other, this is different compared to NASCIO and GAO where categories do not get an individual score. This creates the opportunity for DyAMM to identify individual scores for all 18 EA categories, giving the possibility to have a more detailed analysis of EA maturity. It still provides an additional overall maturity score based on the 14 level scale, comparable to the maturity levels used by NASCIO and GAO.

When looking at the three models that were compared, NASCIO can be defined as a relative simple method for determining the EA maturity of an organization. The NASCIO maturity model is, compared to the other models, a relative straight forward method. The downside of such a model is that the results are less detailed, thus only offering a wide view that in some cases could prohibit in depth analysis. GAO and DyAMM are more thorough with regard to in depth analysis of the maturity state. Both models are described in more detail and elaborate on their statements. DyAMM adds another aspect to it, the individual maturity rating of the key areas. It shows the individual strength or lack of maturity of a key area, meaning that organizations can prioritize their resources for areas that matter most.

## **4.6 Conclusion**

The maturity models discussed in this chapter have many aspects in common. Most current maturity models are based on well established models from a few decades ago, such as the QMMG and CMMI. Compared through a general maturity grid many models show a lot of similar components that are comparable in their use. Beside the similarities there are also some fundamental differences. Section 4.4.1 described the different types of maturity models (staged, continuous and focus area), this partly shows the difference in complexity of models and may also have impact on how detailed their maturity analysis outcomes are. The level of detail and the level of in depth analysis makes a distinction in models that are easy to use and models that ask for more research in order to be able to apply them properly.





## 5. Research Results

This chapter describes the results extracted from the dataset through statistical analysis. Additionally this chapter describes the results from the validation session. The results are visualized in tables and diagrams, additional tables with more (exact) data are available in the Appendix. The results given in this chapter are structured according to the research sub questions that were proposed in Chapter 1, the Introduction. An exception to this is sub question 6: ‘*How does DyAMM compare to other maturity models?*’. In order to improve the structure and readability of this chapter, this question will be immediately answered hereafter.

### 5.1 How does DyAMM compare to other maturity models?

Chapter 4 started with describing maturity models from a historical point of view. Although a few decades old, QMMG and CMMI are still valuable for the development of current and future maturity models. Many of the maturity models currently in use are based on QMMG and CMMI.

From the list of maturity models composed in chapter 4, GAO and NASCIO were chosen for the comparison with DyAMM. The models have been compared through the use of a general maturity grid (figure 4.11). This grid broadly showed that the structure of these maturity models have many similarities but also some important differences.

All maturity models basically consist of three components: Maturity levels, EA categories and Statements. The differences between models can especially be seen in the *number* of levels, categories and statements; the *detail* in which they are described; and the *complexity* or ease of use. A summary of the main properties of each of the three maturity models is shown in table 5.1.

	GAO	NASCIO	DyAMM
Type	Staged	Continuous	Focused
Maturity stages / levels	7	6	14
Key areas	4 (15 sub)	8	18
Statements	59	108	54 ( <i>137 Questions</i> )
Level of detail (Documentation)	Detailed	Low detail	High detail
Usability of model (Complexity)	Complex	Simple	Complex

Table 5.1: Maturity models comparison.

In section 4.4.1 the different types of maturity models (staged, continuous and focus area) were described. Each type has its own properties with regard to how maturity levels are represented in the maturity models. The complexity of models differs, some models are relative easy to use, while others are complex and need more preparation and planning. NASCIO is quite straight forward and can be relatively easy to use compared to GAO and DyAMM. The latter two have extensive documentation and are more complex to use. Additionally GAO and DyAMM both produce a more detailed outcome of a maturity analysis. It is important to consider at what detail the analysis should be performed and which resources are available when assessing the maturity in organizations.

**Conclusion.** The models that were analyzed show many similarities with regard to their structure. Differences can especially be seen in the number of components; the level of detail; and the complexity of the model. It is clear that not every maturity model fits every situation. DyAMM and GAO are detailed and more complex in their use. NASCIO is briefly formulated with little detail, but this could be an advantage for a more ad-hoc analysis.

## 5.2 Analyzing assessments results

Chapter 2, the methodology, already described the properties of the dataset. The following analysis is based on the 56 assessments executed by Sogeti.

### 5.2.1 How mature are the assessed organizations with regard to EAM?

Two approaches were followed in order to find out how mature the assessed organization are with regard to EAM. First it has been determined which maturity scales were reached by the organizations, in this case called the 'Minimum scale'. The second step was to calculate an 'Average scale' for each organization. Both definitions are described in table 5.2. For a detailed description of determining the maturity scale refer to section 4.3.3.2: *The key components of the maturity matrix*.

Scale	Definition
Minimum Scale	The maximum scale which has been reached by fulfilling all key area maturity levels positioned in that column and in all columns to its left.
Average Scale	The average maturity scale for each case has been calculated by summing up the maximum scales reached for all key areas. This number then was divided by 18, the number of key areas.

**Table 5.2: Definitions Minimum and Average scale**

For example in figure 5.1 the assessment indicates a maturity scale of 1. The key areas *Development of architecture*, *Alignment with business* and *Commitment and motivation* all have reached level A, and thus in total reached scale 1. To compute the average maturity scale for figure 5.1, we need to sum up the scores for all 18 key areas. This results in the following calculation:  $(1+0+1+8+0+0+5+6+0+0+0+0+1+5+3+2+0+3) / 18 = 1,94$ . The result is then rounded off to whole numbers, in this case 1,94 becomes 2.

Key Areas \ Scale	0	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Development of Architecture		A			B			C						
2 Use of architecture			A			B				C				
3 Alignment with business		A				B				C				
4 Alignment with the development process			A				B		C					
5 Alignment with operations					A			B			C			
6 Relationship to as-is state					A				B					
7 Roles and responsibilities				A		B					C			
8 Coordination of developments							A			B				
9 Monitoring				A		B		C		D				
10 Quality management								A		B			C	
11 Maintenance of the architectural process							A		B		C			
12 Maintenance of architectural deliverables					A			B					C	
13 Commitment and motivation		A					B		C					
14 Architectural roles and training				A		B			C			D		
15 Use of an architectural method				A						B				C
16 Consultation			A		B				C					
17 Architectural tools							A				B			C
18 Budgeting and planning				A							B		C	

**Figure 5.1: Example of an organization that has reached maturity scale 1**

Table 5.3 shows both the minimum maturity scales but also an average maturity scale.

Minimum Scale			Average Scale		
Scale	Frequency	Percentage	Scale	Frequency	Percentage
0	50	89.3	0	8	14.3
1	4	7.1	1	18	32.1
2	2	3.6	2	16	28.6
≥3	0	0.0	3	7	12.5
Total	56	100	4	5	8.9
			5	1	1.8
			6	0	0.0
			7	1	1.8
			≥8	0	0.0
			Total	56	100

**Table 5.3: Overall maturity distribution**

From the numbers in table 5.3 it can be said that a vast majority of the organizations still resides on scale 0 and no organization reached a scale of 3 or above. The average scale score gives us more information. In comparison with the minimum scale, the average scale scores higher and has a wider spread over more scales. It gives a clear indication that organizations do score higher on some individual key areas, but in many cases do not score regularly over all the key areas. This is also confirmed when we look at all 56 assessments individually. Appendix E shows a list of the 56 assessments, each with a Standard Deviation ( $\sigma$ ) that is derived from 18 maturity scores that belong to the 18 key areas. On average the 56 assessments have a Standard Deviation of 0,7 for the 18 key areas, which is a large number if we take into account that the maturity scores per key area range from 0 to 4 (0, A=1, B=2, C=3, D=4). This means that a large number of the individual assessments score very irregular on all 18 key areas, in other words a significant number of organizations did not score homogeneous across all 18 key areas.

So this shows a lack of balance with regard to the maturity on all 18 key areas. It seems that some key areas are possibly neglected while others get a higher priority. This picture will become more clear when looking at the results in the next section, where key areas are looked at more individually. Additionally in section 5.3.3 this will be further discussed based on the results of the ‘Prioritization of key areas’.

**Conclusion.** At first sight it seems that overall organizations score substantially low. When looking at the average scale, there is more diversification over the first 7 scales, although the vast majority does not score higher than level 4.

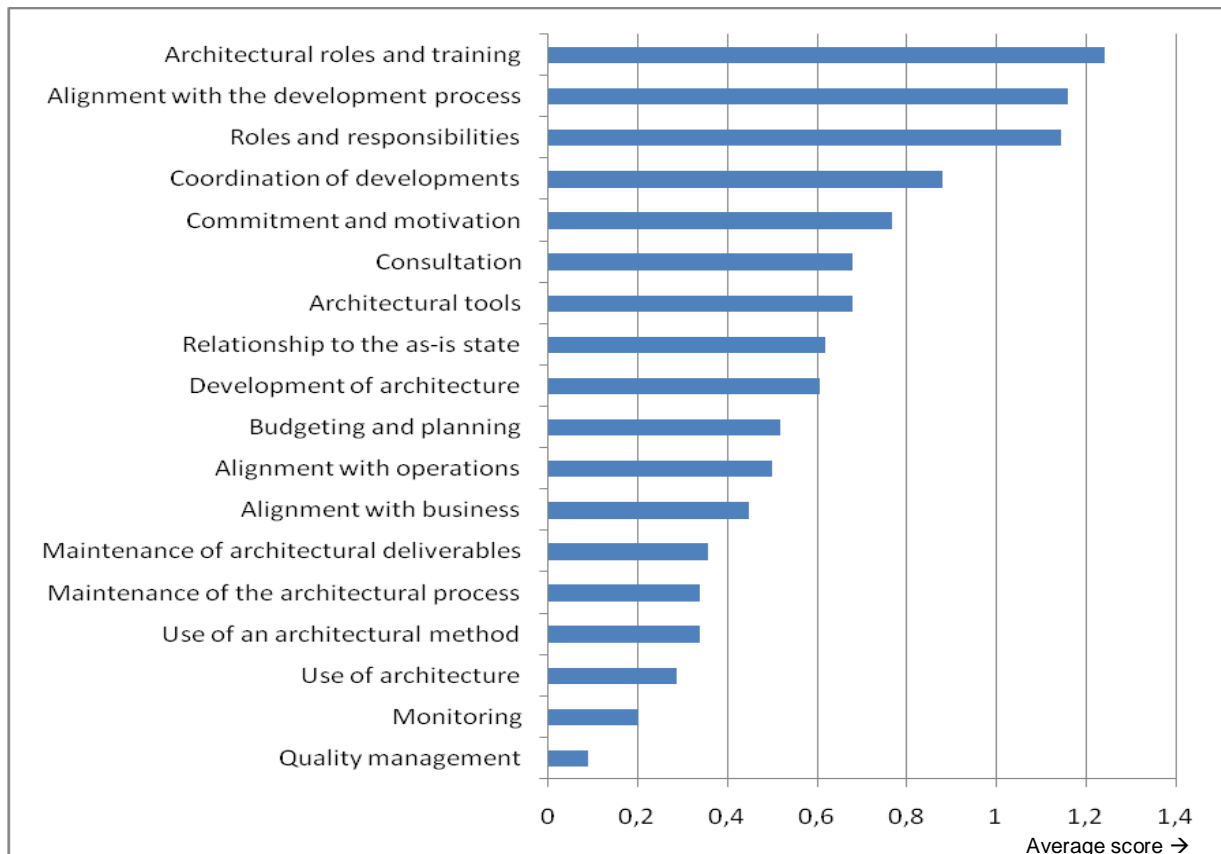
## 5.2.2 How do the assessed organizations perform on the 18 Key Areas with regard to EAM?

The preceding section showed the overall maturity score based on a 14 point scale. This section will give the maturity scores for the 56 organizations based on the 18 individual key areas. Table 5.4 shows an overview of all key areas with their maturity levels: 0, A, B, C and D.

Key area	0	A	B	C	D	Total
Development of architecture	60.7	26.8	3.6	8.9	-	100
Use of architecture	82.2	7.1	10.7	0	-	100
Alignment with business	75	10.7	8.9	5.4	-	100
Alignment with the development process	23.2	41.0	32.2	3.6	-	100
Alignment with operations	66.1	19.6	12.5	1.8	-	100
Relationship to the as-is state	66.1	21.4	12.5	-	-	100
Roles and responsibilities	42.8	5.4	46.4	5.4	-	100
Coordination of developments	51.8	30.4	17.8	-	-	100
Monitoring	89.2	1.8	5.4	1.8	1.8	100
Quality management	92.8	5.4	1.8	0	-	100
Maintenance of the architectural process	76.8	14.3	7.1	1.8	-	100
Maintenance of the architectural deliverables	73.2	21.4	1.8	3.6	-	100
Commitment and motivation	34.0	57.1	7.1	1.8	-	100
Architectural roles and training	10.7	34.0	46.4	7.1	1.8	100
Use of an architectural method	67.8	30.4	1.8	0	-	100
Consultation	42.9	48.2	7.1	1.8	-	100
Architectural tools	48.2	37.5	12.5	1.8	-	100
Budgeting and planning	53.6	41.0	5.4	0	-	100

**Table 5.4: Distribution of organizations over the key area maturity levels**

For each key area the percentage of organizations are presented that reached a certain maturity level. For example, if we look at the key area *Quality management*, 92.8 percent of the organizations scored level 0, while 5.4 percent scored level A and 1.8 percent scored level B. If we take a global look at the table, a few numbers stick out. Firstly the majority of key areas score high on level 0. This means that the maturity of the architecture practices on many aspects is still low. Some key areas have a better spread of organizations over the maturity levels, for example *Alignment with the development process* and *Architectural tools*. It seems that the organizations are more spread over the maturity levels on these aspects of the architecture practice. This may be an indication that some organizations pay more attention to these key areas with a better spread, than to the key areas with a low spread. This could be either because they consider them to be more important or because they are relatively easy to achieve. But these are not the only numbers that attract our attention. If these numbers are translated and visualized to a diagram, it becomes much more clear how the key areas compare to each other. Figure 5.2 shows the average score for each key area ranked from high to low. This average maturity score is calculated by taking the maturity levels 0, A, B, C and D giving them respectively the score of 0, 1, 2, 3 and 4. Not all key areas have the same number of maturity levels, some have 0, A and B while others have an additional C and D level. In order to make it possible to compare all 18 different key areas, all key areas were translated to a 4 point scale with an effective range of 0 to 3 (0,1,2,3).



**Figure 5.2: Average maturity score per key area (with a range of 0 to 3)**

Figure 5.2 shows that the key areas score quite different, some score high while others score low. More strikingly, there is roughly a factor 10 difference between the highest and lowest scoring key area. This means that there is a significant difference between certain key areas with regard to their score and thus performance on EAM. It could also be an indication that the performance on EAM is dependent on a more limited set of key areas than the 18 given key areas.

When we look at the key areas, which according to DyAMM should be addressed in an early stage (scale 1 and 2), three of these six key areas score relatively low on maturity: *Development of architecture* (scale 1), *Alignment with business* (scale 1) and *Use of architecture* (scale 2). If we look further at the key areas of scale 3, three of these five key areas score low: *Monitoring*, *Use of an architectural method* and *Budgeting and planning*. *Monitoring* has a particular low score, this really becomes clear when looking at the individual organizations. Fifty of the 56 organizations (table 5.3) did not score higher than maturity scale 0, that is around 90 percent of all organizations. It seems that *Monitoring* is a weakness in the architecture practice. This key area is positioned at scale 3 in the matrix and thus prevents organizations from attaining scale 3. This explains the fact that none of the assessed organizations score scale 3 or higher. *Quality management* scores even lower than *Monitoring*. But since this key area just only starts at scale 7 with maturity level A, it was to be expected that this key area would score low when organizations have an overall low maturity scale. Since the overall maturity score already is below scale 3, it does not have such a blocking impact as *Monitoring* has at this stage. It nevertheless is lacking a bit behind if we compare it to other key areas. For example, if we compare *Quality management* to *Coordination of developments*, *Maintenance of the architectural process* and *Architectural*

*Tools*. These key areas start at scale 6 with maturity level A, however they do not underperform as much as *Quality management*. *Coordination of developments* and *Architectural tools* even score above average.

There are more key areas which, in comparison to the other key areas, are performing relatively good. In figure 5.2 the top 3 key areas that have the highest score are: *Architectural roles and training* (level A at scale 3), *Alignment with the development process* (level A at scale 2) and *Roles and responsibilities* (level A at scale 3). The three key areas have their maturity level A, relatively early in the maturity development process, all are located within the first three scales. The focus on these key areas is therefore justified, this logically results in a higher maturity score. Formalizing functions such as *Architectural roles and training* and *Roles and responsibilities* seems to be a first step for organizations when they set up an architecture practice.

When looking further at the subject of alignment, there are three key areas shown below that can be compared to each other.

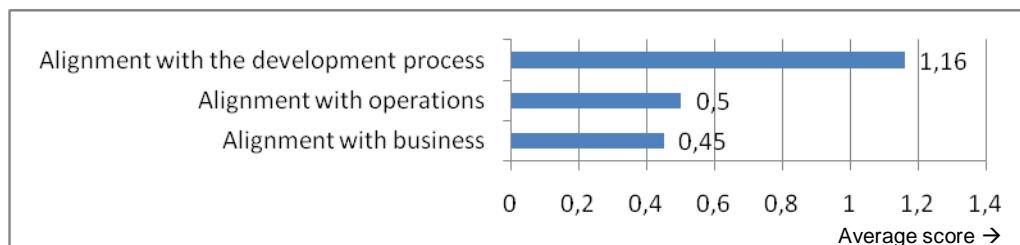


Figure 5.3: Alignment comparison

*Alignment with the development process* clearly outperforms *Alignment with operations* and *Alignment with business*. It looks like most organizations are far more mature in the relation between architecture and projects, than in the relation between architecture and operations or business. The immaturity of the alignment with the business may be a consequence of the fact that architectural thinking most often originates in the IT department. This finding is also confirmed in existing literature. Many articles have been written about Business and IT alignment. The main finding is still that Business and IT alignment are lacking significantly, and thus are a real concern for organizations (Silvius, 2009). This however, does not explain, the low score on alignment with operations. It seems that EA is not really being used as a framework to develop IT as a coherent system from a (technical) operations perspective. This is in contrast with the application of EA as a framework in the development process.

**Conclusion.** In short we may conclude that the architecture practices assessed are still in the early stages of architecture maturity. Architecture as an instrument for providing guidance to a development process is relatively well developed, though follow up in the sense of compliance monitoring is strikingly lacking. The alignment of the architectural choices with the business goals and the existence of an interactive dialogue between architects and business is still underdeveloped.

## 5.3 Evaluation and validation of DyAMM

The dataset can not only be used to evaluate the EA practice, but it also provides information about possible anomalies that might point to flaws in the DyAMM. To fine-tune the DyAMM four kinds of potential instrument anomalies were defined that might distort the result of an assessment. Through quantitative analysis the elements were investigated that did not fit the concept of incremental growth, that were superfluous and that showed interdependency. With this in mind, four kinds of instrument anomalies were identified: *blocking questions*, *blocking levels*, *undifferentiating questions* and *correlations*. A brief overview with the four definitions is given in table 5.5. Furthermore in each corresponding section there is a blue box which contains the definition explained in more detail. Additional information is available in Chapter 2, Research Methodology. The anomalies found under *blocking questions* and *correlations* were further explored in a discussion by an *Expert panel*.

Anomaly	Definition
Blocking question	A question that in at least 10% of the cases was answered with “No”, while if it were answered with “Yes” the organization would move up at least two maturity levels for the key area concerned.
Undifferentiating question	A question that at least 85% of the assessments answered with “Yes”.
Blocking level	A key area maturity level that is not achieved by at least 10% of the cases, while if these organizations would achieve the level, their <u>overall</u> score would be at least 2 scales higher.
Correlation	A dependency between two key areas with a significance of $\geq 0.05$ .

**Table 5.5: Potential instrument anomalies**

### 5.3.1 Are there anomalies with regard to the assessment questions, and with regard to the distribution of maturity levels on the 14 point scale? And if so, what is the impact of these anomalies?

**Blocking question:** A question that in at least 10% of the cases was answered with “No”, while if it were answered with “Yes” the organization would move up at least two maturity levels for the key area concerned.

*Blocking questions may indicate that a question should be moved to a higher maturity level.*

Quantitative analysis provided three blocking questions shown in table 5.6.

Nr.	Question	Key area	Percentage blocked
18	Is there a clear relationship between the architecture and the organization’s business goals?	Alignment with business	10.7
44	Has a policy been formulated concerning the as-is state (existing processes, organizational structures, information, applications and technical infrastructure)?	Relationship to the as-is state	12.5
48	Does the architecture have an official status in the organization?	Roles and responsibilities	14.3

**Table 5.6: Blocking questions**

There are three possible responses to a blocking question: (1) the question should be moved to a higher maturity level, (2) the question should be rephrased or (3) the question represents a genuine weakness (in the context of EA, but not the instrument) and should remain as it is. In order to determine the response, the opinion of experts is used during the discussion of an



*expert panel* of seven persons on the blocking questions, as presented in table 5.7. To determine whether questions should be rephrased, the understandability and relevance of the questions were examined. To determine whether the questions should be moved to a higher maturity level, a question was asked about in which maturity phase the question becomes relevant.

Nr.	Question	Understandable?	Relevant?	Phase?
18	Is there a clear relationship between the architecture and the organization's business goals?	Yes (6)	Yes (7)	1 (4)
		No (1)	No (0)	2 (3)
				3 (0)
44	Has a policy been formulated concerning the as-is state (existing processes, organizational structures, information, applications and technical infrastructure)?	Yes (7)	Yes (7)	1 (5)
		No (0)	No (0)	2 (2)
				3 (0)
48	Does the architecture have an official status in the organization?	Yes (7)	Yes (6)	1 (3)
		No (0)	No (1)	2 (3)
				3 (1)

**Table 5.7: Results expert opinion on blocking questions**

The numbers in brackets in table 5.7 show the number of respondents giving the answer indicated. The rightmost column shows the maturity phase in which according to the experts the question mentioned becomes relevant. Phase 1 translates to scale 0-3 in the matrix, phase 2 to scale 4-8 and phase 3 to scale 9-13. Table 5.6 shows that the questions are well-understood and relevant. This indicates that the questions need not be removed or rephrased in order to be understood. Regarding the position of the question, there is more deviation between the experts. Most consensus is about question 44. Most participants agree that the question is relevant in the early stages of an architecture practice. For the other two questions about half of the participants place them in the early stages, and the other half place them in the middle stage, when architecture is more or less on its way. In the matrix this would mean between scale 4 and 8 which would indicate a move of the questions to a next level. The difference in opinion regarding question 48 concentrated on the fact that in some organizations a formal approval at an early stage is important, while in others it is not. This seems organization dependent. Question 18 is one of the two questions that are associated with level A of the key area *Alignment with business*. Interestingly, the other question, question 19, 'Is the architecture evaluated in terms of the business goals?', serves as a blocking question for 7% of the assessments. This suggests two possibilities: (1) level A might be positioned too early in the matrix and should be moved to a higher scale or (2) the questions are not appropriate to level A and must be reconsidered. As the experts rank *Alignment with business* as the second most important key area in the early stages (see also section 5.3.3), we may conclude that the positioning of level A of *Alignment with business* at scale 1 needs no reconsideration. However, the questions for level A need to be further investigated. A possibility is that the current questions are moved to a higher maturity level, while new questions are added that are more appropriate to the early stages of EA.

**Conclusion.** Question 44 is well-understood and deemed relevant to the early stages of an architecture practice, thus this question is left as it is (response option 3). Question 48 is well-understood and deemed relevant to the early stages of an architecture practice for formally oriented organizations. As the DyAMM is still generic for all organizations, it is preferred to leave this question too as it is (option 3). Question 18 is well-understood, but the discussion indicates that it might be too advanced for the early stages. This goes for its companion



question 19 as well. Which leaves us to consider whether other questions would be more appropriate to this level.

**Undifferentiating question:** A question that at least 85% of the assessments answered with “Yes”.

*An undifferentiating question does not differentiate between organizations. Undifferentiating questions seem to be superfluous and might possibly be removed, making the use of the matrix more efficient.*

Two undifferentiating questions were found shown in table 5.8.

Nr.	Question	Key area	Percentage Yes
95	Are money and time allocated to architecture?	Commitment and motivation - A	87.5
102	Does the role of architect exist in the organization?	Architectural roles and training - A	87.5

**Table 5.8: Undifferentiating questions**

The fact that these two questions have such a high percentage of “Yes” score, can be partly explained by the fact that not many organizations will perform an architecture assessment if they do not allocate any time or money to architecture, or in some way or other recognize the role of architect. It might be worthwhile, however, to reconsider these two questions. As question 102 is the only question for level A of *Architectural roles and training*, this also explains the high percentage of level A for this key area.

**Conclusion.** Only two undifferentiating questions were found that had a percentage of “Yes” higher than 85 percent. Of course it is possible to find more undifferentiating questions by lowering the threshold. It seems that especially the second question of table 5.8 could possibly have a misleading impact on the score of the key area *Architectural roles and training*. This can be solved by adjusting this question and adding more differentiating questions for level A of this key area.

**Blocking level:** A key area maturity level that is not achieved by at least 10% of the cases, while if these organizations would achieve the level, their overall score would be at least 2 scales higher.

*Blocking levels may indicate that a maturity level should be moved to the right in the matrix.*

Quantitative analysis provided three cases that contained a level preventing them from moving up two scales. Two organizations scored 0 on the key area *Development of architecture*, preventing them from moving from scale 0 to scale 2. One organization scored 0 on the key area *Alignment with business*, preventing it also to move up from scale 0 to scale 2. These numbers are too small to consider these levels blocking levels, as the threshold of 10% is not reached by far.

**Conclusion.** We may conclude that the DyAMM does not contain any serious blocking levels at this moment. Of course when overall maturity of organizations increases blocking levels could appear on higher scales.

### 5.3.2 Are there dependencies between different key areas?

**Correlation:** A dependency between two key areas with a significance of  $\geq 0.05$ .

*A correlation may indicate a strong connection between key areas. It can also indicate that key areas should be combined.*

A significant number of the 56 assessments scored level zero on maturity on a high number of key areas. When looking for correlations, this would result in many correlations that are based on “zero scores” of the key areas. In order to be able to look for more useful correlations, all zeros were filtered out, and only correlations were used that were based on a score higher than zero. Removing zeros also created missing values. As can be seen in Appendix F, the letter N represents the number of assessments that count for the given correlation. Several correlations were found, but only correlations that comply with all of the following conditions were accepted:

- We stated that  $N \geq 28$ , in other words at least 50 percent of the total number of assessments should correlate.
- The significance (Sig. 2-tailed) should be  $\geq 0.05$ .

After analyzing all relationships between the 18 items, three correlations were found that complied with the conditions mentioned above. One of these three correlations complies with a significance level of 5%: between *Alignment with the development process* and *Commitment and motivation* ( $r=.37$ ;  $p=.04$ ). There are two correlations that meet a significance level of 1%: between *Commitment and motivation* and *Architectural roles and training* ( $r=.55$ ;  $p=.00$ ) and between *Architectural roles and training* and *Alignment with the development process* ( $r=.43$ ;  $p=.01$ ).

We presented the three significant correlations found to the experts, asking them whether they could explain the correlations. This generated some suggestions, like the idea that when management shows commitment to architecture, projects will be more inclined to take architecture into account and more attention will be paid to the function of architect. Or, when architects are better trained, they will generate commitment more easily. An explanation offered for the third correlation was that as functions and roles are important in many development processes, alignment is easier when the function of architect is formally established. Not one explanation emerged as being the most likely, however.

**Conclusion.** Further research is needed to investigate why these correlations were found, and no significant correlation between other items. The potential application of factor analysis to explore this, however, is not feasible due to the number of observations ( $N=56$ ). Literature indicates that a sample size of 56 cases is too small in order to obtain reliable results (Comrey, 1992; Gorsuch, 1983).

### 5.3.3 Which key areas are most important when applying EA?

Part of the discussion of the expert panel was also investigating which of the 18 key areas are most important for EA. Since the results from the analysis of assessments showed us that most organizations are scoring low on maturity, it was a logical step to investigate which key areas should have priority when being in the startup-phase of an EA.

The experts each got a limited budget of 270,000 euro to be spent on 18 key areas, keeping in mind that the amount represented the amount of time and energy spent in the startup-phase of an EA. In figure 5.4 the *percentages* for all 18 key areas are shown. The percentages are based on the average of the budgets that are allocated by the individual experts. The result should give an indication of the relative importance of different key areas.

Additionally the average maturity scores per key area acquired from the assessments in section 5.2.2 (figure 5.2: Average maturity score per key area) have also been added to figure 5.4. However data obtained from both results (the expert panel and the DyA assessments) are not based on the same measurement scale, also the results from the DyA assessments are based on a more complex score system in contrast to the expert panel. It is difficult to compare these results on a one-to-one basis. Both results have been normalized to a scale of 100 percent, which makes it possible to compare both groups. The exact numbers of figure 5.4 are provided in Appendix G.

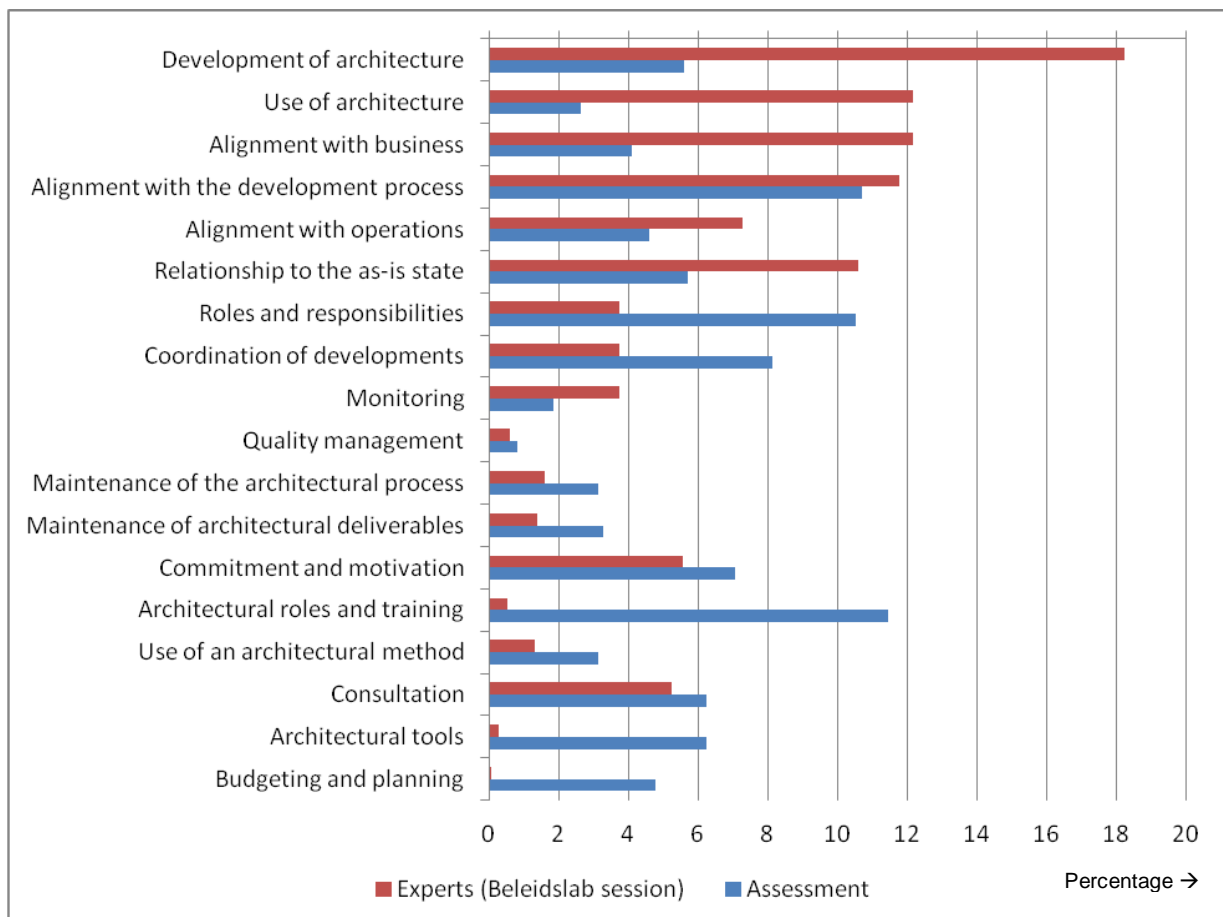


Figure 5.4: Prioritization of key areas by EA experts. Percentage of total budget.

## The experts

The key area with the highest amount of budget allocated by the experts is *Development of architecture* (18.3%). It clearly gets the most attention from the experts, which is to be expected in a startup-phase of an EA. Following at some distance (near 12%) are the key areas *Use of architecture*, *Alignment with business*, *Alignment with the development process* and *Relationship to the as-is state*. These five key areas are according to the experts the most important when starting up an EA.

The other key areas seem to be of much less importance, they all get significant less resources. The key areas *Quality management*, *Architectural roles and training* and *Architectural tools*, each got less than 1% of the total budget. *Budgeting and planning* received close to 0% of the total budget, indicating that the experts found this key area irrelevant at the startup of an EA.

## Experts vs. Assessments

Figure 5.4 shows a clear difference in what experts *think* that is important and the average maturity score of organizations *measured* by the DyA assessments. Only one key area, *Alignment with the development process*, scores high in both groups. According to the experts *Alignment with business* and *Use of architecture* are very important, but assessment results show that both key areas score relatively low. It is striking that *Architectural roles and training* does not have any priority, while the assessment score shows that it outperforms all other key areas.

It seems that there are very large differences between the prioritization of key areas by EA experts and the actual status of the (average) maturity of these key areas as a result from the DYA assessments. To further investigate the degree in difference, a mathematical approach (based on a normalized scale of 100%) has been used by applying a vector to both groups. This gives an impression of a possible correlation between these two observations. The calculations for these vectors are explained below, the exact numbers can be found in Appendix G.

One vector represents the expert panel findings:  $V_{\text{exp}} (x_1, \dots, x_{18})$ .

The other one represents the assessment findings:  $V_{\text{ass}} (y_1, \dots, y_{18})$ .

Both vectors will be normalized using:

$$\|V_{\text{exp}}\| = \sqrt{(V_{\text{exp}} \cdot V_{\text{exp}})} = \sqrt{\sum_{i=1}^{18} x_i^2} \quad \text{and} \quad \|V_{\text{ass}}\| = \sqrt{(V_{\text{ass}} \cdot V_{\text{ass}})} = \sqrt{\sum_{i=1}^{18} y_i^2}$$

The normalized vectors (length 1) will be:

$$V_{\text{nexp}} = V_{\text{exp}} (x_1, \dots, x_{18}) / \sqrt{\sum_{i=1}^{18} x_i^2} \quad \text{and} \quad V_{\text{nass}} = V_{\text{ass}} (y_1, \dots, y_{18}) / \sqrt{\sum_{i=1}^{18} y_i^2}$$

The inner product of these vectors can be interpreted as a measure for correlation. So the inner product of the normalized vectors equals:

$$V_{\text{nexp}} \cdot V_{\text{nass}} = \sum_{i=1}^{18} x_i y_i \div \left( \sqrt{\sum_{i=1}^{18} x_i^2} \cdot \sqrt{\sum_{i=1}^{18} y_i^2} \right) = 0.666$$

So the angle between the two vectors is 84.19 rad or 48.24°. This factor indicates there is no evidence of a significant correlation between the two sets of figures representing ‘assessment’ and ‘expert panel’.

It is difficult to find a plausible explanation for these clear differences in prioritization of key areas between both the expert panel and assessments. Some possible indicators for these differences could be:

- The average maturity scores from the assessments do not particularly resemble the startup-phase of an EA. Many organizations were past the startup-phase of an EA practice.
- For some key areas it can be relative easy to accomplish a higher maturity score with limited resources.
- Enterprise Architects have a top-down approach based on strategy and vision, while real life practice is bottom-up. Theory and practice are mismatching.

**Conclusion.** Results based on the expert panel shows that there are very big differences between the priorities given to certain key areas. Some areas are given large amounts of resources while others receive nearly nothing. Results from the expert panel compared to the results from the DyA assessments show striking differences in prioritization of key areas. Further research is necessary to find out what caused these differences.



## 6. Conclusion

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This thesis focused on the research of the Dynamic Architecture Maturity Matrix (DyAMM) and many relevant aspects that came across when looking at the subject of Enterprise Architecture Maturity (EAM). DyAMM is used as an instrument for assessment and improvement of the architecture process within organizations.

In essence we looked at DyAMM with two objectives: 1) *analyzing assessment results* where it concerns EAM and 2) *evaluating and validating the Maturity Matrix* as an instrument. In order to reach these two objectives, 56 assessments were collected, interviews were held, an expert session was organized and a literature review was performed.

Whereas a lot is written about EA in general, EAM still does not get the focus it needs. Especially literature related to assessing maturity in organizations is still not widely available. The literature review showed that EAM and maturity models still need a lot of research. This thesis initially leaned heavily on the data coming from DyA maturity assessments. The data showed to be very useful to get insights with respect to EAM. After a first analysis of the available assessments, it became clear that more research was desirable to be able to interpret the data and understand the context. For example to assess the assessment questionnaire and to get an idea of possible ambiguity of assessment questions. Therefore a meeting with experts was organized to gather the additional data and context information. This created the opportunity to compare the results acquired from the assessments and the outcome of the expert panel.

The first objective was to have a qualitative and quantitative analysis of the maturity assessments and the data produced. The initial question we asked was ‘how mature are the assessed organizations with regard to EAM’? On the 14 point DyAMM scale, around 90% scored level 0 while no organization scored higher than level 2. By analyzing all 56 assessments individually, it turned out that most organizations scored irregularly across the 18 key areas; computing the Standard Deviation for all assessments confirmed this. Even when looking at the average scale (explained in section 5.2.1), it only showed slightly better results. There is more diversification over the first 7 scales, although the vast majority does not score higher than level 4. Overall it can be concluded that the organizations that were assessed were scoring low on maturity.

Secondly we looked at how the assessed organizations performed on the 18 Key Areas with regard to EAM. The performance for all key areas was also relatively low. There is roughly a factor 10 difference between the highest (*Architectural roles and training*) and lowest (*Quality management*) scoring key area, they respectively scored around 1.2 and 0.1 on a maximum scale of 3 (Figure 5.2). We may conclude that the architecture practices assessed are still in the early stages of architecture maturity.

The second objective of the research was to evaluate and validate DyAMM as a useful instrument. So the DyAMM assessment method was analyzed in order to find out if there were anomalies that could influence assessment results in an undesirable way. An analysis of all 56 assessments showed potential problems in some assessment questions and maturity levels. The expert session was used to find out to what extent these anomalies posed a problem for the reliability of the DyA assessment method. Two questions were found that did not differentiate between organizations. In other words 87.5 percent answered both questions with *Yes*, making these questions less suitable for the assessment. No further major flaws were found, but minor enhancements are recommended for further fine tuning of DyAMM.

A further look at the 18 key areas showed that there were several relationships between key areas. After using statistical software three significant correlations were found: 1) *Alignment with the development process* and *Commitment and motivation*, 2) *Commitment and motivation* and *Architectural roles and training*, 3) *Architectural roles and training* and *Alignment with the development process*. The three correlations were presented during the expert session, asking them whether they could explain the correlations. Not one explanation emerged as being the most likely, however.

The expert session was also used to investigate the prioritization of key areas. The question was asked: ‘*which key areas are most important when applying an EA*’? The result is a list of 18 key areas with very large differences between the priorities given to certain key areas. While some areas were given large amounts of resources others receive nearly nothing. The results from the expert panel were compared to the results of the DyA assessments, this shows striking differences in prioritization of key areas (figure 5.4). A vector was calculated for both groups (experts and assessment), this confirmed that there is no significant correlation between the results of both groups. While some possible explanations are given, further research is necessary to find out what caused these differences.

The final step in this research was the comparison of DyAMM to other maturity models. DyAMM was compared to two other models, GAO and NASCIO. All maturity models basically consist of three components: Maturity levels, EA categories and Statements. The differences between models can especially be seen in the *number* of levels, categories and statements; the *detail* in which they are described; and the *complexity* or ease of use. DyAMM and GAO are detailed and more complex in their use. NASCIO is briefly formulated with little detail, but this could be an advantage for a more ad-hoc analysis.

In this research we tried to find an answer to the main research question below:

*“What is the usefulness and added value of the Maturity Matrix? And therefore, what is the relevance of data generated from using the Dynamic Architecture Maturity Matrix as an instrument for assessment and improvement of the architecture process?”*

The Dynamic Architecture Maturity Matrix generated a lot of data for this research. Analysis of the assessment data gave an impression of the maturity of studied organizations, it showed big differences in maturity between key areas and uncovered some relations between key areas. The data can be valuable for individual organizations, but also for researchers and professionals that are looking for insights in the current state of EA maturity in organizations as a whole. During this research the Maturity Matrix was also validated, the assessment data was used to find anomalies in questions and maturity levels. However no major flaws were found. The Maturity Matrix shows its added value by being a robust assessment instrument. It shows that it can be a useful instrument for organizations that would like to analyze the *current state* of their EA; and last but not least it gives direction on *how to progress* to a higher maturity level.



## 7. Discussion

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As with all research projects is the case, there are limitations. This chapter briefly discusses the limitations of this research and several points for future research.

A possible limitation of this research is the sample that was used. Sample properties are described in section 2.5. The sample contains 56 assessments that were gathered during a period of several years. Assessments were gathered from organizations from different countries, but the Netherlands are overrepresented. It would be better to have a more homogenous sample that contains assessments that were executed in the same but shorter time frame, and either the same country or evenly distributed over several countries.

With regard to sample size, limitations apply to both the assessments and the expert panel. It would be better to have a larger number of assessments. This could improve the reliability on statistical tests, and add some possibilities to use tests that require larger sample sizes (such as factor analysis). The number of experts was limited by the availability of experts that could be present at the Beleidslab session. The reliability of the research results could be greatly improved by solving these limitations.

A great part of the research results is about the 18 key areas. This is the area where future research is really needed. The 18 key areas should be analyzed more thorough with regard to mutual relations. It was difficult to research patterns between the 18 key areas, because of the limited sample size (statistical tests were very limited). It would be interesting to know which key areas affect each other.

Additionally the difference of the prioritization of key areas between the expert panel and the DyAMM assessment could be investigated more thorough. There seems to be a gap between what experts think is important and what is really measured by the assessments. An interesting question would be if this difference in prioritization can be traced back to the difference in backgrounds between the experts in the expert panel and the people who participated in the assessments. For example, do decision makers such as CEOs and CIOs take fundamental different decisions with regard to EAM in comparison to architects?

The DyAMM assessment questionnaire contains 137 questions. Although all questions have been analyzed, only a limited number of questions could be further investigated in depth by the expert panel. In future research it would be useful to investigate all 137 questions by an expert panel and additionally receive more feedback. This could further improve the DyAMM assessment method.



## 8. Bibliography

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- Allega, P. (2006). Case Study: Basic Enterprise Architecture Metrics to Communicate Enterprise Architecture Effectiveness. Gartner.
- Aziz, S. & Obitz, T. (2007). *Enterprise Architecture is Maturing*. Infosys Enterprise Architecture Survey 2007.
- Bahill, T. (2009). *What is CMMI? Powerpoint lecture slides 2009*. Systems and Industrial Engineering University of Arizona. Retrieved from: <http://www.sie.arizona.edu/sysengr/slides/CMMI.ppt>
- Bruin, T. D., Rosemann, M., Freeze, R., & Kulkarni, U. (2005). Understanding the main phases of developing a maturity assessment model. *Proceedings of the 16th Australasian Conference on Information Systems*. Sydney.
- Campbell, A. (2009). EA maturity model. Retrieved from: <http://iea.wikidot.com/ea-maturity-model>
- Chief Information Officers Council (2010). Federal Enterprise Architecture (FEA). Retrieved from: <http://www.cio.gov>
- CMMI (2002). CMMI<sup>SM</sup> for Systems Engineering, Software Engineering, Integrated Product and Process Development, and Supplier Sourcing; (CMMISE/ SW/IPPD/SS, V1.1) Staged Representation; CMU/SEI-2002-TR-012 ; ESC-TR-2002-012.
- Comrey, A. L. & Lee, H. B., (1992). *A first course in factor analysis*, Hillsdale, New Jersey: Erlbaum.
- Crosby, P. B. (1979). *Quality is Free*. New York: McGraw-Hill.
- Crosby, P.B. (1996). *Quality is Still Free: making quality certain in uncertain times*. New York: McGraw-Hill.
- Deloitte (2010). Het Business Maturity Model. Retrieved from: [http://www.deloitte.com/view/nl\\_NL/nl/diensten/consulting/](http://www.deloitte.com/view/nl_NL/nl/diensten/consulting/)
- DeSanctis, G., & Gallupe, R. B. (1987). A Foundation for the Study of Group Decision Support Systems. *Management Science*, 33(5), 589-609.
- Fountain, J. E. (2004). *Prospects for the virtual state*. National Center for Digital Government.
- Fraser, P., Moultrie, J. & Gregory, M. (2002). *The use of maturity models / grids as a tool in assessing product development capability*. IEEE International Engineering Management Conference, Cambridge, 19-20 August 2002.

- Gartner (2005). Enterprise Architecture Process Model (Meta Group). Retrieved from: <http://www.gartner.com>
- Gardner, R. A. (2004). *The Process-Focused Organization: A Transition Strategy for Success*. ASQ, Quality Press, Milwaukee (2004).
- Godfrey, S. (2008). *What is CMMI? NASA presentation*. Retrieved from: <http://software.gsfc.nasa.gov/docs/What%20is%20CMMI.ppt>
- Gorsuch, R. L. (1983). *Factor Analysis*. (2nd. Ed). Hillsdale, NJ: Erlbaum.
- GroupSystems MeetingRoom (2001). *Concepts Guide*. Tucson, Arizona (1990 - 2001).
- Guevara, D. (2006). *Making EA work (Part I)*. Retrieved from: [http://www.ebizq.net/topics/real\\_time\\_enterprise/features/6966.html](http://www.ebizq.net/topics/real_time_enterprise/features/6966.html)
- Hansen, V. T. (2006). *Enterprise Architecture: how to establish and sustain a successful EA*. IT University Copenhagen (Master's Thesis).
- Institute of Electrical and Electronics Engineers (IEEE) (2000). 1471-2000 - IEEE Recommended Practice for Architectural Description for Software-Intensive Systems. Retrieved from: <http://www.iso-architecture.org/ieee-1471/ieee-1471-faq.html>
- ISO-Architecture (2011). Retrieved from: <http://www.iso-architecture.org/ieee-1471/afs/frameworks-table.html>
- ISO/IEC (2008). Information Technology - Process Assessment - Part 7: Assessment of Organizational Maturity - ISO/IEC TR 15504-7:2008(E). ISO/IEC, Geneva (2008).
- James, B. (2008). *Architecture&Process: Enterprise Architecture Benefits*. Metastorm Inc. Renaissance Washington, DC.
- Koomen, T. & Pol, M. (1999). *Test Process Improvement, a practical step-by-step guide to structured testing*. Addison-Wesley, Boston (1999).
- Landry, S. & Hotle, M. (2008). *Maturity Model Overview: Application Organizations*. Gartner.
- Langenberg, K. & Wegmann, A. (2004). *Enterprise Architecture: What Aspects is Current Research Targeting?* Technical Report Laboratory of Systemic Modeling Ecole Polytechnique Fédérale de Lausanne, Switzerland.
- Lankhorst, M. (2005). *Enterprise Architecture at Work: Modelling, Communication, and Analysis*. (First edition). Berlin; New York: Springer.
- Lapkin, A. (2005). *Business Strategy Defines Enterprise Architecture Value*. Gartner.
- Lapkin, A (2006). *Activity Cycle Overview: Enterprise Architect*. Gartner.

- Lee, J., Lee, D., & Kang, S. (2009). vPMM: a value based Process Maturity Model. In: Roger, L., Gonzu, H., Huaikou, M. (eds) *Computer and Information Science 2009*, pp. 193--213. Springer, Heidelberg (2009).
- Maier, A. M., Moultrie, J., & Clarkson, P. J. (2008). A Review of Maturity Grid based Approaches to Assessing Organizational Capabilities. *Academy of Management Annual Meeting*, 8-13 August. Academy of Management, California (2008).
- Mettler, T. (2010). Thinking in terms of design decisions when developing maturity models. *International Journal of Strategic Decision Sciences*, 1(4), 2010, pp. 76-87.
- Mettler, T., Rohner, P., & Winter, R. (2010). Towards a Classification of Maturity Models in Information Systems. *Management of the Interconnected World*. Berlin, Heidelberg: Physica, 2010, pp. 333-340.
- National Association of State Chief Information Officers (NASCIO) (2003). *National Association of State Chief Information Officers: Enterprise Architecture Maturity Model*. Retrieved from: <http://www.nascio.org>.
- National Association of State Chief Information Officers (NASCIO) (2010). Website: <http://www.nascio.org>
- Obitz, T. & Babu, K. M. (2009). Enterprise Architecture Expands its Role in Strategic Business Transformation. *Infosys Enterprise Architecture Survey 2007*.
- Object Management Group (2008). Business Process Maturity Model (BPMM) - Version 1.0 (1 June 2008). Retrieved from: <http://www.omg.org/spec/BPMM/1.0/PDF>
- Paulk, M., et al. (1993). Key practices of the capability maturity model, Version 1.1, Technical Report CMU/SEI-93-TR-25. Software Engineering Institute, Carnegie Mellon University, Pittsburgh, PA.
- Plazaola, L., Flores, J., Silva, E., Vargas, N. & Ekstedt, M. (2007). An Approach to Associate Strategic Business-IT Alignment Assessment to Enterprise Architecture.
- Ross, J. W., Weill, P., & Robertson, D. (2006). *Enterprise architecture as strategy: creating a foundation for business execution*. Boston, Mass.: Harvard Business School Press.
- Rosser, B. (2006a). Measuring the Value of Enterprise Architecture: Value Context. Gartner.
- Rosser, B. (2006b). Measuring the Value of Enterprise Architecture: Metrics and ROI. Gartner.
- Schekkerman, J. (2003). *How to survive in the Jungle of Enterprise Architecture Frameworks: Creating Or Choosing An Enterprise Architecture Framework*. Trafford Publishing.

- Schekkerman, J. (2004). A comparative survey of enterprise architecture frameworks. The Open Group, Enterprise Architecture Practitioners Congress Brussels, April 2004. Retrieved from: [http://www.enterprise-architecture.info/Images/Documents/Comparative\\_Survey\\_of\\_EA\\_Frameworks.pps](http://www.enterprise-architecture.info/Images/Documents/Comparative_Survey_of_EA_Frameworks.pps)
- Schekkerman, J. (2006). Extended Enterprise Architecture Maturity Model (E2AMM). Retrieved from: <http://www.enterprise-architecture.info/Images/E2AF/E2AMMv2.PDF>
- Scott, D. (2003). IT Operations Management Is Undergoing Transformation. Gartner. Donna Scott, 29 May 2003.
- Scott, D., Pultz, J. E., Holub, E., Bittman, T. J., & McGuckin, P. (2007). Introducing the Gartner IT Infrastructure and Operations Maturity Model. Gartner. Donna Scott, Jay E. Pultz, Ed Holub, Thomas J. Bittman, Paul McGuckin. 1 October 2007.
- SEI (2006). Software Architecture definition. Retrieved from: <http://www.sei.cmu.edu>
- Sessions, R. (2007). Building Distributed Applications: A Comparison of the Top Four Enterprise-Architecture Methodologies. Microsoft Developer Network (MSDN). (May 2007). Retrieved from: <http://msdn.microsoft.com/en-us/library/bb466232.aspx>
- Shah, H. & El Kourdi, M. (2007). Frameworks for Enterprise Architecture. *IT Professional*, vol. 9, no. 5, pp. 36-41, Sept.-Oct. 2007, doi:10.1109/MITP.2007.86
- Silvius, A. J. G. (2009). Business and IT Alignment: What we know and what we don't know. *International Conference on Information Management and Engineering* (2009). Utrecht University of Applied Sciences. Utrecht, the Netherlands.
- Sogeti Architects (2009, 2010). Personal interviews.
- SPSS (2006). Statistical Package for the Social Sciences 15.0 Base User's Guide. Retrieved from: <http://support.spss.com/productsext/spss/documentation/SPSSforWindows/index.html#15>
- Suter, R. (2007). Securing Strategic Benefit from Enterprise Architectures. Defense AT&L: January-February 2007. Retrieved from: <http://www.cioindex.com/nm/articlefiles/21624-SecuringStrategicBenefitFromEA.pdf>
- Szyszkka, B. (2009). *Analysis and Classification of Maturity Models in Enterprise Architecture Management*. Bachelor thesis, Technical University of Munich.
- Tekinerdogan, B. (2000). *Synthesis-Based Software Architecture Design*. PhD thesis (March 23, 2000).
- 't Hart, H., Van Dijk, J., De Goede, M., Jansen, W., & Teinissen, J. (1998). *Onderzoeksmethoden*. Amsterdam.
- The Free Dictionary. Definition: 'Maturity'. Retrieved from: <http://www.thefreedictionary.com/maturity>

- The Open Group (2011). *The Open Group Architecture Framework (Togaf)*. Retrieved from: <http://www.opengroup.org>
- Tucker, C. & Aron, D. (2005). *Applying Enterprise Architecture*. Gartner.
- United Nations Statistics Division (2002). *International Standard Industrial Classification of All Economic Activities (ISIC) Revision 3.1*. Retrieved from: <http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=17&Lg=1>
- U. S. Department of Commerce (2007). *Enterprise Architecture Capability Maturity Model v1.2*. Retrieved from: [http://ocio.os.doc.gov/ITPolicyandPrograms/Enterprise\\_Architecture/PROD01\\_004935](http://ocio.os.doc.gov/ITPolicyandPrograms/Enterprise_Architecture/PROD01_004935)
- U.S. Department of the interior (2010). *Enterprise Architecture information*. Retrieved from: <http://www.doi.gov/ocio/architecture/eainfo2.htm>
- U.S. Governance Accountability Office (GAO) (2010a). *Organizational Transformation: A Framework for Assessing and Improving Enterprise Architecture Management (Version 2.0)*. Retrieved from: <http://www.gao.gov/assets/80/77233.pdf>
- U.S. Governance Accountability Office (GAO) (2010b). Website: <http://www.Gao.gov>
- U.S. Office of Management and Budget (OMB) (2010). *Enterprise Architecture Assessment Framework v3.1*. Retrieved from: [http://www.whitehouse.gov/sites/default/files/omb/assets/fea\\_docs/OMB\\_EA\\_Assessment\\_Framework\\_v3\\_1\\_June\\_2009.pdf](http://www.whitehouse.gov/sites/default/files/omb/assets/fea_docs/OMB_EA_Assessment_Framework_v3_1_June_2009.pdf)
- Vaidyanathan, S. (2005). *Enterprise Architecture in the Context of Organizational Strategy*. BPTrends November 2005.
- Van den Berg, M., & Van Steenbergen, M. (2006). *Building an Enterprise Architecture Practice: Tools, Tips, Best Practices, Ready-to-Use Insights Series*. New York: Springer-Verlag.
- Van Steenbergen, M. (2011). *Maturity and effectiveness of enterprise architecture*. (Doctoral dissertation). Utrecht University.
- Van Steenbergen, M., Van den Berg, M., & Brinkkemper, S. (2007a). An Instrument for the Development of the Enterprise Architecture Practice. In (Cardoso, J.; Cordeiro, J.; Filipe, J., Ed.): *International Conference on Enterprise Information Systems* (3). Pages 14–22. Berlin, Germany. 2007. Springer.
- Van Steenbergen, M., Van den Berg, M., & Brinkkemper, S. (2007b): A Balanced Approach to Developing the Enterprise Architecture Practice. In: Filipe, J., Cordeiro, J., Cardoso, J. (Eds.) *Enterprise Information Systems*, LNBIP 12, 240-253 (2007).
- Van Steenbergen, M., Schipper, J., Bos, R., & Brinkkemper, S. (2009). The Dynamic Architecture Maturity Matrix: Instrument Analysis and Refinement. *The 4th Workshop on Trends in Enterprise Architecture Research*. ICSSOC Stockholm (2009).
- Venkatraman, N. (1989). The Concept of Fit in Strategy Research: Toward Verbal and Statistical Correspondence. *Academy of Management Review*. 14 (3), 423-444.

- Venkatraman, N. & Camillus, J.C. (1984). Exploring the Concept of “Fit” in Strategic Management. *Academy of Management Review*. 9 (3), 513-525.
- Wagter, R., Van den Berg, M., Luijpers, J., & Van Steenberghe, M. (2005). *Dynamic enterprise architecture: how to make it work*. Hoboken, N.J.: John Wiley & Sons.
- Weill, P. (2007). Innovating with Information Systems: What do the most agile firms in the world do? MIT Center for Information Systems Research. *Sixth e-Business Conference, Barcelona Spain, 27 March 2007*. Retrieved 2010 from: [http://www.iese.edu/en/files/6\\_29338.pdf](http://www.iese.edu/en/files/6_29338.pdf)
- Weill, P. & Woodham, R. (2002). Dont just lead, govern: Implementing effective IT governance. MIT CISR WP#326. April 2002.
- Weiss, D. (2008). Enterprise Architecture Measurement Examples: Run the Business. Gartner.
- West, D., Bittner, K., Glenn E. (2002). *Ingredients for Building Effective Enterprise Architectures, 2002, The Rational Edge*. Retrieved from: [http://www106.ibm.com/developerworks/rational/library/content/RationalEdge/nov02/EnterpriseArchitectures\\_TheRationalEdge\\_Nov2002.pdf](http://www106.ibm.com/developerworks/rational/library/content/RationalEdge/nov02/EnterpriseArchitectures_TheRationalEdge_Nov2002.pdf)
- Wikipedia (2010). Capability Maturity Model Integration. Retrieved from: [http://en.wikipedia.org/wiki/Capability\\_Maturity\\_Model\\_Integration](http://en.wikipedia.org/wiki/Capability_Maturity_Model_Integration)
- Zachman, J.A. (1987). A Framework for Information Systems Architecture. *IBM Systems Journal, Volume 26, (3)*, 1987.



## 9. Appendices

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- Appendix A. Interviews / Example of simple Interview
- Appendix B. Beleidslab expert session – Agenda
- Appendix C. Beleidslab expert session – Notulen
- Appendix D. Reliability analysis (formal/informal)
- Appendix E. Standard deviation 56 maturity assessments
- Appendix F. Correlations
- Appendix G. Vector calculation

## Appendix A: Interviews / Example of simple Interview

### Vragenlijst DYA assessments

Naam assessor:

Organisatie:

Datum:

Doel: Het volledig maken en het toetsen van de kwaliteit van het assessment

#### Volledigheid

1. Heb je nog meer assessments in je bezit?
2. Het compleet maken van de assessmentlijst (zie excel sheet):
  - a. Bron van input (bv. Cursus):
  - b. Markt Sector:
  - c. Functie(s):
  - d. Land:
  - e. Datum:
3. De assessments globaal doorlopen.
  - a. DYAgnoSetool controleren (uitleg bij aangepaste tools).

Hoe heb je de uiteindelijke matrix opgesteld? Want je hebt uit meerdere DYAgnoSet een matrix opgesteld.
  - b. Rapport/Powerpoint controleren/doorlopen.

#### Kwaliteit:

4. Waar is het assessment afgenomen? In welke vorm is het assessment afgenomen (bv. Cursus, workshop etc)?
5. Wie heeft de antwoorden gegeven/ingevuld? Op basis waarvan (bv. Overleg in een groep, consensus)?
6. Wat was de rol/functie van de persoon?
7. Geeft het assessment een mening van een persoon weer? Of is het een representatief beeld van de onderneming/afdeling?
8. Zijn de antwoorden op enige wijze getoetst? Dus heeft er een vorm van validatie plaatsgevonden?
9. Is er een voorbereiding/introductie/toelichting geweest die voor iedereen hetzelfde was of dezelfde uitgangspositie verzorgde (begrippen, definities, scope etc.)?
10. Hoe betrouwbaar schat je zelf het assessment in?

#### Eenduidigheid en scope:

11. Wat is de definitie van architectuur (geweest)? Was deze definitie ook duidelijk voor de geïnterviewde persoon?
12. Gaat het assessment in op de totale architectuur, dus business, informatie, applicatie en technische infrastructuur?

## Appendix B: Beleidslab expert session - Agenda

### Agenda – Beleidslab 22-05-2008

**Doel:**

- Valideren van de resultaten
- Andere invalshoeken op de resultaten verkrijgen
- Discussie

**Deliverables:**

- Verklaringen voor de vragen
- Verklaringen voor de correlaties
- Lijst van areas die volgens experts prioriteit moeten hebben

**Agenda:**

Tijd: 16:00 – 18:00

	<b>Activiteit</b>	<b>Tijd</b>
	Ontvangst en koffie	15:30
1	Presentatie onderzoek	16:00
2	Uitleg Groupsystems	16:15
3	Korte survey	16:20
4	Selectie van vragen bekijken (vragen die volwassenheid blokkeren)	16:30
5	Prioriteiten areas opstellen (welke areas zijn belangrijk voor architectuur)	17:00
6	Correlaties bekijken (brainstormen over verklaringen)	17:20
7	Resultaten presenteren + bespreken (vergelijken met de groepsresultaten)	17:45
	Afsluiting	18:00

## **Inhoud:**

### **1. Presentatie**

Inleiding onderzoek

Achtergrond / context (matrix uitleggen)

Onderzoeks vraag

Onderzoeks aanpak

Verwachte resultaten

Duidelijk kort uitleggen over DYA matrix, en welke onderdelen hier relevant zijn.

### **2. Introductie Groupsystems**

Waarom Groupsystems?

Hoe werkt het?

### **3. Korte survey**

Doel: Informatie verkrijgen over de achtergrond van de experts die aanwezig zijn.

Deliverable: Lijst met antwoorden op vragen

Hoe: "Survey tool"

Open vragen:

1. Bij welke organisatie bent u werkzaam?
2. Hoeveel werknemers heeft de organisatie?
3. Wat is uw huidige functie?
4. Hoeveel jaar heeft u ervaring met architectuur?
5. Hoeveel architecten zijn er werkzaam binnen uw organisatie?

### **4. Selectie van DyAMM vragen bekijken**

Selectie van de vragen die nee scoren, waardoor een veel hoger maturity level (net) niet wordt behaald.

Doel: De selectie vragen doorlopen en mogelijke problemen achterhalen in de vraagstelling.

Deliverable: Lijst met issues/verbeterpunten/verklaringen voor de geselecteerde vragen

Hoe: "Survey tool" en "Brainstorming" of "Topic commenter"?

1. Eerst beantwoordt men voor iedere controle vraag de drie vragen.
2. De resultaten worden getoond, en de interessante vragen eruit gelicht.
3. Door middel van discussie kan men toelichten waarom op de vragen zo geantwoord is.

Voor elke vraag moet men drie vragen beantwoorden:

1. Begrijpt u wat er met de vraag bedoeld wordt, m.a.w. is de vraag duidelijk geformuleerd? (ja of nee)
2. Is deze vraag relevant voor het werken onder architectuur? (ja of nee)
3. Voor welk fase in architectuur is de vraag het meest van toepassing? (a, b of c)
  - a. De beginfase waarbij er net met architectuur begonnen wordt.
  - b. De middenfase waarbij architectuur al in redelijke mate toegepast wordt.
  - c. De eindfase waarbij architectuur vrijwel volwassen wordt toegepast.

**Controle vraag 1:***Aandachtsgebied: Afstemming met business*

"Is de relatie tussen de architectuur en de businessdoelen van de organisatie duidelijk?"

**Controle vraag 2:***Aandachtsgebied: Afstemming met business*

"Wordt de architectuur getoetst aan de businessdoelen?"

**Controle vraag 3:***Aandachtsgebied: Relatie met bestaande situatie*

"Is er beleid geformuleerd met betrekking tot de bestaande situatie (bestaande processen, organisatorische inrichting, informatievoorziening en technische infrastructuur)?"

**Controle vraag 4:***Aandachtsgebied: Verantwoordelijkheden en bevoegdheden*

"Heeft de architectuur een officiële status binnen de organisatie?"

Deel 1: Vragen invullen

Deel 2: Alle vragen weergeven met resultaten

Deel 3: Discussie per vraag voeren

**5. Prioriteiten key-areas opstellen**

Doel: Vergelijken van de huidige lijst met (hoog/laag) scorende areas met die van de expert groep.

Deliverable: Een lijst met de 18 key-areas in de volgorde van de belangrijkste area (waar men veel aandacht aan moet besteden) tot aan de onbelangrijke areas.

Hoe: Bepaalde tool

1. Eerst mag iedereen het bedrag verdelen over de 18 aandachtsgebieden.
2. Daarna maken we de resultaten zichtbaar en kunnen we discussiëren over waarom men op bepaalde aandachtsgebieden veel of weinig geld heeft ingezet.

Er is een bedrag van 270.000 euro beschikbaar om te investeren in architectuur. De architectuur van de organisatie bevindt zich nog in de opstartfase/beginfase. Het beschikbare bedrag moet verdeeld worden over de 18 aandachtsgebieden. Hierbij moet men letten op de hoeveelheid **tijd en energie** die men wil besteden aan een aandachtsgebied tijdens de **beginfase van architectuur**.

Aandachtsgebied	Bedrag
1. Opstellen van architectuur	
2. Gebruik van architectuur	
3. Afstemming met business	
4. Afstemming met ontwikkelproces	
5. Afstemming met beheer	
6. Relatie met bestaande situatie	
7. Verantwoordelijkheden en bevoegdheden	
8. Coordinatie van ontwikkelingen	
9. Bewaking	
10. Kwaliteitsmanagement	
11. Beheer architectuurproces	
12. Beheer architectuurproducten	
13. Commitment en motivatie	
14. Architectuurfuncties en -opleidingen	
15. Toepassingsgraad van architectuurmethode	
16. Overleg	
17. Architectuurtools	
18. Begroting en planning	

## 6. Correlaties bekijken

Er zijn verbanden gevonden tussen enkele aandachtsgebieden.

Doel: Het zoeken naar mogelijke verklaringen voor de correlaties.

Deliverable: Een lijst met mogelijke verklaringen voor de correlaties.

Hoe: "Brainstorm tool"

1. In eerste instantie moet iedereen zelf individueel brainstormen.
2. Daarna maken we de resultaten zichtbaar en kan iedereen op elkaar reageren en commentaar toevoegen.

### **Correlatie 1:**

Afstemming met ontwikkelproces **MET** Commitment en motivatie

### **Correlatie 2:**

Commitment en motivatie **MET** Architectuurfuncties en -opleidingen

### **Correlatie 3:**

Architectuurfuncties en -opleidingen **MET** Afstemming met ontwikkelproces

## 7. Discussie

Het is de bedoeling dat na elk onderwerp een kleine discussie kan plaatsvinden, zodat er consensus ontstaat over de resultaten.

## 8. Resultaten bespreken

Uiteindelijk moeten de behaalde resultaten van de sessie voorgelegd worden.

### **Checklist:**

Hand-outs presentatie

Hand-outs sessie

Alternatief programma op papier

## Appendix C: Beleidslab expert session - Notulen

### Notulen Beleidslab sessie

**Naam vergadering:** Beleidslab  
**Datum:** 22 mei 2008  
**Plaats:** Utrecht

#### Aanwezigen

Jurjen Schipper (voorzitter)	Aanwezig
Marlies van Steenberghe	Aanwezig
Eelco van Mens	Aanwezig
Jos Melssen	Aanwezig
Erwin Winkel	Aanwezig
Frank Howldar	Aanwezig
Marcel Wijnhorst	Aanwezig
Richard Lugtigheid	Aanwezig
Dick Groeneveld	Aanwezig
Marijn Plomp	Aanwezig
Berend Roukes	Aanwezig
Ria van Rijn	Afwezig
Amanda Meeusen (notulist)	Aanwezig

#### Controle vraag 1: 'Is de relatie tussen de architectuur en de businessdoelen van de organisatie duidelijk?'

De reden om voor een beginfase te kiezen is, omdat dit de motivatie is voor de businessdoelen, oftewel een doel te bereiken. Het is makkelijker om af te stemmen als er nog niet zo veel staat, deze kun je nog aanpassen. Als er al 150 principes staan is het heel moeilijk om ze dan nog aan te passen.

De reden om voor de middenfase te kiezen is omdat het doel onderweg pas helder wordt. In de praktijk is het namelijk niet zo makkelijk om de businessdoelen helder te krijgen.

De vraag is of het om businessdoelen gaat of om de gewone doelen als meer omzet, meer winst, meer besparen enz. De gewone doelen zijn voor alle organisaties namelijk ongeveer hetzelfde en de businessdoelen wijken af. Men vraagt zich af wat de toegevoegde waarde van de doelen is als je net begint. Je moet eerst beginnen en daarna pas de doelen boven water krijgen. De architectuur moet eerst verkocht worden door de toegevoegde waarde te laten zien en daarna pas concretiseren.

Het ligt eraan wat de drijfveer is, namelijk het opzetten van een architectuur of het volgen van businessdoelen. De vraag die ontstaat is wat de beginfase en de middenfase precies zijn en dat het daaraan ligt. Dus is de beginfase de doelen opstellen of is dit dat je al met deze doelen werkt. Daarnaast ontstaat de vraag of dit betrekking heeft op de gehele architectuur inclusief de inhoud.

#### Controle vraag 2: 'Wordt de architectuur getoetst aan de businessdoelen?'

De beginfase moet getoetst worden, omdat dit de afstemming met de business is. Dit moet meteen getoetst worden ondanks dat het nog niet af is. En daarna moet je blijven afstemmen in elke fase.

De middenfase is de afstemming, dus juist dan moet je toetsen.

In de eindfase moet afgestemd worden, omdat je iets pas kunt toetsen als het af is. In het begin ben je nog aan het zoeken en dit kun je dus niet toetsen.

Er is echter een verschil tussen toetsen en sturen. In het begin is het nog sturen aan het einde is het toetsen. Architectuur ontwikkelen is sturing en geen toetsing.

**Controle vraag 3: 'Is er een beleid geformuleerd met betrekking tot de bestaande situatie (bestaande processen, organisatorische inrichting, informatievoorziening en technische infrastructuur)?'**

De keuze om de middenfase is, omdat het beleid dan pas vast gaat leggen. Daarvoor zijn andere zaken belangrijker.

Achteraf is het niet goed begrepen dat het om de huidige situatie gaat in relatie tot de toekomstige situatie.

Het is belangrijk om de huidige situatie te beschrijven, omdat deze moet blijven draaien. De toekomstige situatie is er ook meestal eentje die vaak niet gebruikt wordt en zo het raam uit gaat. Anderen zijn het daar niet mee eens en zeggen dat het de toekomstige situatie is waarop beslissingen worden gemaakt.

**Controle vraag 4: 'Heeft de architectuur een officiële status binnen de organisatie?'**

De vraag rijst of de officiële status betekent dat je architect wordt genoemd. Het gaat er namelijk meer om of je onder architectuur werkt. Architectuur pikt men namelijk soms niet, omdat er meerdere mislukte implementaties zijn en dan nemen ze projectmanagement of governance wel aan. Anderen geven aan dat het erom gaat dat de architectuur officieel is goedgekeurd en de vraag niet gaat om het werken onder architectuur.

Het hoort in de beginfase, omdat dit afgetikt moet worden door de directie, vervolgens gaat het naar de interne controle om te laten toetsen. Het moet goedgekeurd worden als architectuur anders heb je geen architectuur. Je kunt echter wel werken onder architectuur zonder dat je goedkeuring hebt. Alleen niet elke bedrijf pikt architectuur zonder officiële goedkeuring. In de eindfase is de formaliteit er in ieder geval zeker wel.

**Prioriteiten Key-areas**

Men geeft aan dat ze liever hun energie zouden willen verdelen in plaats van geld, omdat afstemmen geen budget kost. Hetzelfde geldt voor commitment en motivatie, maar is wel het belangrijkste en onbetaalbaar.

Het opstellen van de architectuur kost de meeste tijd en geld. De bewaking van de architectuur is niet belangrijk in de beginfase, maar hiermee bewijs je de architectuur wel. Tevens zorgt commitment voor minder bewaking.

Het opstellen van de architectuur en het gebruik hiervan horen bij elkaar net als commitment en afstemmen met de business.

De bewaking is achteraf en de afstemming in het begin en de latere fasen, dit heeft te maken met het vertrekpunt.

Bewaking doe je door met mensen te spreken over hoe zij met de architectuur denken om te gaan.

De reden om voor 50 % van het budget aan het ontwikkelproces te besteden is, omdat het leuk is om architectuur te maken, maar wat veel belangrijker is, is dat er iets mee gebeurt.



In het DYA boek mist hoe je iets conform architectuur moet opleveren. Dit staat echter wel in het Maturity Model.

### **Correlatie 1: Afstemming met ontwikkelproces met Commitment en motivatie**

Alle opmerkingen zijn ongeveer hetzelfde. Punt 2 klopt volgens iedereen. Commitment in architectuur leiden tot betere afstemming. Als je weet wat je doet is het resultaat anders. Er is een verschil tussen commitment van ontwikkelaars en die van management.

### **Correlatie 2: Commitment en motivatie met Architectuurfuncties en –opleidingen.**

Medewerkers willen serieus genomen worden. Er ontstaat commitment als je architect als naam hebt, omdat je dan serieus genomen wordt. Als je de naam hebt gekregen betekend het dat je als belangrijk wordt gezien. Dit is echter wel commitment van boven naar beneden.

### **Correlatie 3: Architectuurfuncties en –opleidingen met Afstemming met ontwikkelproces.**

Deze correlatie was lastig en heeft de minste reacties gekregen. Ontwikkelaars willen ontwikkelen maar er zijn ook architecten, dus er moet afgestemd worden. Architectuur komt meestal vanuit het ontwikkelproces. De status als architect helpt, waardoor je beslissingen kunt maken. Voor een architect is het ontwikkelproces belangrijk en je krijgt meer aanzien als architect. Ontwikkelaars en architecten komen vanuit twee afdelingen, daardoor ontstaat kruisbestuiving.

### **Overige gedachten**

Men vraagt zich af wat voor type mensen de onderzoeken heeft ingevuld. Zij hebben namelijk een bepaald beeld dat samen hangt met hun functie. De assesment geeft echter niet aan wat de voorkeur geeft, maar geeft aan wat er daadwerkelijk gebeurt in een organisatie.

Er wordt opvallend veel geld besteed aan 'intern geneuzel' over functies, maar heel weinig geïnvesteerd in het gebruik van de architectuur.

Als er geen veranderingen zijn, heb je niks aan architectuur, omdat je dan niks hebt om regels op te leggen.

## Appendix D: Reliability analysis (formal/informal)

Key area	Type	N	Mean	Std.Deviation	t-value	p-value
Development of architecture	Informal	31	0,613	1,054	0,051	0,959
	Formal	25	0,600	0,764		
Use of architecture	Informal	31	0,290	0,643	0,058	0,954
	Formal	25	0,280	0,678		
Alignment with business	Informal	31	0,387	0,882	-0,563	0,576
	Formal	25	0,520	0,872		
Alignment with the development process	Informal	31	1,129	0,885	-0,317	0,753
	Formal	25	1,200	0,764		
Alignment with operations	Informal	31	0,645	0,839	1,558	0,125
	Formal	25	0,320	0,690		
Relationship to the as-is state	Informal	31	0,548	0,810	0,983	0,330
	Formal	25	0,360	0,569		
Roles and responsibilities	Informal	31	1,097	1,076	-0,362	0,719
	Formal	25	1,200	1,041		
Coordination of developments	Informal	31	0,774	0,845	1,235	0,222
	Formal	25	0,520	0,653		
Monitoring	Informal	31	0,452	1,028	2,194	0,033
	Formal	25	0,000	0,000		
Quality management	Informal	31	0,065	0,250	-0,594	0,555
	Formal	25	0,120	0,440		
Maintenance of the architectural process	Informal	31	0,355	0,755	0,185	0,854
	Formal	25	0,320	0,627		
Maintenance of architectural deliverables	Informal	31	0,355	0,709	-0,027	0,978
	Formal	25	0,360	0,700		
Commitment and motivation	Informal	31	0,839	0,638	0,892	0,376
	Formal	25	0,680	0,690		
Architectural roles and training	Informal	31	1,516	0,811	-0,364	0,718
	Formal	25	1,600	0,913		
Use of an architectural method	Informal	31	0,290	0,461	-0,790	0,433
	Formal	25	0,400	0,577		
Consultation	Informal	31	0,645	0,755	-0,400	0,691
	Formal	25	0,720	0,614		
Architectural tools	Informal	31	0,742	0,773	0,687	0,495
	Formal	25	0,600	0,764		
Budgeting and planning	Informal	31	0,516	0,677	-0,024	0,981
	Formal	25	0,520	0,510		

**Table A.1: Reliability analysis of formal and informal assessments**

## Appendix E: Standard Deviation 56 maturity assessments

Assessments	Std. Dev.		Assessments	Std. Dev.
Case 1	1,110		Case 29	0,383
Case 2	0,705		Case 30	0,575
Case 3	0,428		Case 31	0,575
Case 4	0,878		Case 32	0,784
Case 5	0,511		Case 33	0,514
Case 6	0,832		Case 34	0,698
Case 7	1,092		Case 35	0,383
Case 8	0,826		Case 36	0,922
Case 9	0,608		Case 37	0,895
Case 10	0,732		Case 38	1,098
Case 11	0,850		Case 39	0,575
Case 12	0,698		Case 40	0,857
Case 13	0,428		Case 41	0,895
Case 14	0,608		Case 42	0,461
Case 15	0,594		Case 43	1,029
Case 16	0,895		Case 44	1,188
Case 17	0,963		Case 45	0,786
Case 18	0,698		Case 46	0,000
Case 19	0,943		Case 47	0,943
Case 20	0,732		Case 48	0,705
Case 21	0,428		Case 49	0,970
Case 22	0,485		Case 50	0,323
Case 23	0,732		Case 51	0,732
Case 24	0,514		Case 52	0,784
Case 25	0,594		Case 53	0,850
Case 26	0,383		Case 54	0,705
Case 27	0,000		Case 55	0,428
Case 28	0,608		Case 56	0,958
Average of all Standard Deviations = 0,694				

**Table A.2: Standard Deviations of all 56 assessments**

## Appendix F: Correlations

Significant correlations that comply with the following rules are marked in red:

- We stated that  $N \geq 28$ , in other words at least 50 percent of the total number of assessments should correlate.
- The significance (Sig. 2-tailed) should be  $\geq 0.05$ .

		Development of architecture	Use of architecture	Alignment with business	Alignment with the development process	Alignment with operations	Relationship to the as-is state	Roles and responsibilities	Coordination of developments	Monitoring
Development of architecture	Pearson Correlation	1	.000	.132	.304	.000	.312	.246	.478	.189
	Sig. (2-tailed)		1.000	.779	.207	1.000	.496	.358	.116	.879
	N	22	6	7	19	7	7	16	12	3
Use of architecture	Pearson Correlation	.000	1	.525	.227	.471	-.408	.272	-.316	. <sup>a</sup>
	Sig. (2-tailed)	1.000		.285	.527	.286	.495	.447	.541	.
	N	6	10	6	10	7	5	10	6	1
Alignment with business	Pearson Correlation	.132	.525	1	.249	.420	.657	.255	-.234	. <sup>a</sup>
	Sig. (2-tailed)	.779	.285		.460	.348	.157	.423	.578	.
	N	7	6	14	11	7	6	12	8	1
Alignment with the development process	Pearson Correlation	.304	.227	.249	1	.641**	.299	.124	.292	.375
	Sig. (2-tailed)	.207	.527	.460		.004	.244	.505	.156	.534
	N	19	10	11	43	18	17	31	25	5
Alignment with operations	Pearson Correlation	.000	.471	.420	.641**	1	.336	.296	.299	.000
	Sig. (2-tailed)	1.000	.286	.348	.004		.313	.284	.320	1.000
	N	7	7	7	18	19	11	15	13	3
Relationship to the as-is state	Pearson Correlation	.312	-.408	.657	.299	.336	1	.469	.238	. <sup>a</sup>
	Sig. (2-tailed)	.496	.495	.157	.244	.313		.091	.433	.
	N	7	5	6	17	11	19	14	13	2
Roles and responsibilities	Pearson Correlation	.246	.272	.255	.124	.296	.469	1	.000	-.375
	Sig. (2-tailed)	.358	.447	.423	.505	.284	.091		1.000	.534
	N	16	10	12	31	15	14	32	20	5
Coordination of developments	Pearson Correlation	.478	-.316	-.234	.292	.299	.238	.000	1	.686
	Sig. (2-tailed)	.116	.541	.578	.156	.320	.433	1.000		.201
	N	12	6	8	25	13	13	20	27	5
Monitoring	Pearson Correlation	.189	. <sup>a</sup>	. <sup>a</sup>	.375	.000	. <sup>a</sup>	-.375	.686	1
	Sig. (2-tailed)	.879	.	.	.534	1.000	.	.534	.201	.
	N	3	1	1	5	3	2	5	5	6
Quality management	Pearson Correlation	. <sup>a</sup>	. <sup>a</sup>	. <sup>a</sup>	1.000**	. <sup>a</sup>	. <sup>a</sup>	. <sup>a</sup>	. <sup>a</sup>	. <sup>a</sup>
	Sig. (2-tailed)	.	.	.	.000	.	.	.000	.	.
	N	1	1	1	3	0	1	3	2	1
Maintenance of the architectural process	Pearson Correlation	.083	-.612	.522	-.031	.540	.325	.693*	-.115	. <sup>a</sup>
	Sig. (2-tailed)	.876	.272	.478	.920	.211	.433	.013	.769	.
	N	6	5	4	13	7	8	12	9	1
Maintenance of architectural deliverables	Pearson Correlation	.441	.113	.000	.624*	.435	.565	.356	.702	-.1000**
	Sig. (2-tailed)	.322	.809	1.000	.013	.329	.145	.233	.078	.
	N	7	7	5	15	7	8	13	7	2
Commitment and motivation	Pearson Correlation	.203	.696	.779**	.371*	.730**	.315	.309	.381	.000
	Sig. (2-tailed)	.436	.055	.005	.044	.001	.273	.109	.098	1.000
	N	17	8	11	30	16	14	28	20	5
Architectural roles and training	Pearson Correlation	.236	.499	.549	.428**	.447	.348	.120	.327	.000
	Sig. (2-tailed)	.303	.142	.052	.005	.055	.170	.521	.096	1.000
	N	21	10	13	41	19	17	31	27	6
Use of an architectural method	Pearson Correlation	. <sup>a</sup>	.354	.436	.479	.707*	.250	.729**	.239	. <sup>a</sup>
	Sig. (2-tailed)	.000	.437	.280	.052	.033	.516	.001	.479	.000
	N	13	7	8	17	9	9	17	11	3
Consultation	Pearson Correlation	.396	.258	.174	.172	.448	.665*	.199	.567*	.894
	Sig. (2-tailed)	.128	.537	.680	.390	.125	.013	.386	.011	.106
	N	16	8	8	27	13	13	21	19	4
Architectural tools	Pearson Correlation	.053	.612	. <sup>a</sup>	-.097	-.346	-.185	.343	-.456	-.258
	Sig. (2-tailed)	.884	.272	.000	.669	.270	.510	.163	.087	.742
	N	10	5	6	22	12	15	18	15	4
Budgeting and planning	Pearson Correlation	.191	-.354	.061	-.174	-.263	.289	-.032	.378	-.158
	Sig. (2-tailed)	.478	.437	.887	.416	.434	.389	.891	.149	.765
	N	16	7	8	24	11	11	21	16	6

\*\* . Correlation is significant at the 0.01 level (2-tailed).

\* . Correlation is significant at the 0.05 level (2-tailed).

a . Cannot be computed because at least one of the variables is constant.

**Table A.3a: Correlations between key areas (key areas 1 to 9)**

		Quality management	Maintenance of the architectural process	Maintenance of architectural deliverables	Commitment and motivation	Architectural roles and training	Use of an architectural method	Consultation	Architectural tools	Budgeting and planning
Development of architecture	Pearson Correlation	. <sup>a</sup>	.083	.441	.203	.236	. <sup>a</sup>	.396	.053	.191
	Sig. (2-tailed)	.	.876	.322	.436	.303	.000	.128	.884	.478
	N	1	6	7	17	21	13	16	10	16
Use of architecture	Pearson Correlation	. <sup>a</sup>	-.612	.113	.696	.499	.354	.258	.612	-.354
	Sig. (2-tailed)	.	.272	.809	.055	.142	.437	.537	.272	.437
	N	1	5	7	8	10	7	8	5	7
Alignment with business	Pearson Correlation	. <sup>a</sup>	.522	.000	.779**	.549	.436	.174	. <sup>a</sup>	.061
	Sig. (2-tailed)	.	.478	1.000	.005	.052	.280	.680	.000	.887
	N	1	4	5	11	13	8	8	6	8
Alignment with the development process	Pearson Correlation	1.000**	-.031	.624*	.30*	.428**	.479	.172	-.097	-.174
	Sig. (2-tailed)	.000	.920	.013	.044	.005	.033	.390	.669	.416
	N	3	13	15	30	41	17	27	22	24
Alignment with operations	Pearson Correlation	. <sup>a</sup>	.540	.435	.730**	.447	.707*	.448	-.346	-.263
	Sig. (2-tailed)	.	.211	.329	.001	.055	.033	.125	.270	.434
	N	0	7	7	16	19	9	13	12	11
Relationship to the as-is state	Pearson Correlation	. <sup>a</sup>	.325	.565	.315	.348	.250	.665*	-.185	.289
	Sig. (2-tailed)	.	.433	.145	.273	.170	.516	.013	.510	.389
	N	1	8	8	14	17	9	13	15	11
Roles and responsibilities	Pearson Correlation	. <sup>a</sup>	.693*	.356	.309	.120	.729**	.199	.343	-.032
	Sig. (2-tailed)	.000	.013	.233	.109	.521	.001	.386	.163	.891
	N	3	12	13	28	31	17	21	18	21
Coordination of developments	Pearson Correlation	. <sup>a</sup>	-.115	.702	.381	.327	.239	.567*	-.456	.378
	Sig. (2-tailed)	.	.769	.078	.098	.096	.479	.011	.087	.149
	N	2	9	7	20	27	11	19	15	16
Monitoring	Pearson Correlation	. <sup>a</sup>	. <sup>a</sup>	-1.000**	.000	.000	. <sup>a</sup>	.894	-.258	-.158
	Sig. (2-tailed)	.	.	.	1.000	1.000	.000	.106	.742	.765
	N	1	1	2	5	6	3	4	4	6
Quality management	Pearson Correlation	1	. <sup>a</sup>	. <sup>a</sup>	-.500	.870	. <sup>a</sup>	1.000**	1.000**	. <sup>a</sup>
	Sig. (2-tailed)	.	.	.	.667	.130	.	.	.000	.
	N	4	2	2	3	4	0	2	3	2
Maintenance of the architectural process	Pearson Correlation	. <sup>a</sup>	1	-.043	-.039	.107	.632	.111	.112	. <sup>a</sup>
	Sig. (2-tailed)	.	.	.912	.909	.728	.178	.760	.775	.000
	N	2	13	9	11	13	6	10	9	8
Maintenance of architectural deliverables	Pearson Correlation	. <sup>a</sup>	-.043	1	.478	.350	.606	.425	-.310	. <sup>a</sup>
	Sig. (2-tailed)	.	.912	.	.116	.200	.111	.168	.383	.000
	N	2	9	15	12	15	8	12	10	9
Commitment and motivation	Pearson Correlation	-.500	-.039	.478	1	.550**	.747**	.190	-.132	.155
	Sig. (2-tailed)	.667	.909	.116	.	.001	.001	.410	.568	.513
	N	3	11	12	37	36	15	21	21	20
Architectural roles and training	Pearson Correlation	.870	.107	.350	.550**	1	.594**	.244	.246	.116
	Sig. (2-tailed)	.130	.728	.200	.001	.	.009	.194	.215	.580
	N	4	13	15	36	50	18	30	27	25
Use of an architectural method	Pearson Correlation	. <sup>a</sup>	.632	.606	.747**	.594**	1	.299	-.167	-.067
	Sig. (2-tailed)	.	.178	.111	.001	.009	.	.279	.645	.806
	N	0	6	8	15	18	18	15	10	16
Consultation	Pearson Correlation	1.000**	.111	.425	.190	.244	.299	1	-.097	-.108
	Sig. (2-tailed)	.	.760	.168	.410	.194	.279	.	.711	.668
	N	2	10	12	21	30	15	32	17	18
Architectural tools	Pearson Correlation	1.000**	.112	-.310	-.132	.246	-.167	-.097	1	-.149
	Sig. (2-tailed)	.000	.775	.383	.568	.215	.645	.711	.	.582
	N	3	9	10	21	27	10	17	29	16
Budgeting and planning	Pearson Correlation	. <sup>a</sup>	. <sup>a</sup>	. <sup>a</sup>	.155	.116	-.067	-.108	-.149	1
	Sig. (2-tailed)	.	.000	.000	.513	.580	.806	.668	.582	.
	N	2	8	9	20	25	16	18	16	26

\*\* Correlation is significant at the 0.01 level (2-tailed).

\* Correlation is significant at the 0.05 level (2-tailed).

a. Cannot be computed because at least one of the variables is constant.

**Table A.3b: Correlations between key areas (key areas 10 to 18)**

## Appendix G: Vector calculation

	Key areas	<b>V<sub>ass</sub> (y<sub>1</sub>,...,y<sub>18</sub>)</b>		<b>V<sub>exp</sub>(x<sub>1</sub>,...,x<sub>18</sub>)</b>	
		<b>Assessment</b>		<b>Experts</b>	
		Score	Percentage	Score	Percentage
1	Development of architecture	0,60714	5,59	345000	18,25
2	Use of architecture	0,28571	2,63	230000	12,17
3	Alignment with business	0,44643	4,11	230000	12,17
4	Alignment with the development process	1,16071	10,69	222500	11,77
5	Alignment with operations	0,50000	4,61	137500	7,28
6	Relationship to the as-is state	0,61905	5,70	200000	10,58
7	Roles and responsibilities	1,14286	10,53	71000	3,76
8	Coordination of developments	0,88095	8,12	71000	3,76
9	Monitoring	0,20000	1,84	71000	3,76
10	Quality management	0,08929	0,82	11000	0,58
11	Maintenance of the architectural process	0,33929	3,13	30000	1,59
12	Maintenance of architectural deliverables	0,35714	3,29	26000	1,38
13	Commitment and motivation	0,76786	7,07	105000	5,56
14	Architectural roles and training	1,24286	11,45	10000	0,53
15	Use of an architectural method	0,33929	3,13	25000	1,32
16	Consultation	0,67857	6,25	99000	5,24
17	Architectural tools	0,67857	6,25	5000	0,26
18	Budgeting and planning	0,51786	4,77	1000	0,05
	<b>Totaal</b>	10,85357	100,00	1890000	100,00

Table A.4: Maturity scores (normalized) for Assessment and Experts.

<b>V<sub>exp</sub>.V<sub>ass</sub></b>		
Inner product	Square (y)	Square (x)
102,11	31,29	333,21
32,04	6,93	148,09
50,05	16,92	148,09
125,90	114,37	138,59
33,51	21,22	52,93
60,36	32,53	111,98
39,56	110,88	14,11
30,49	65,88	14,11
6,92	3,40	14,11
0,48	0,68	0,34
4,96	9,77	2,52
4,53	10,83	1,89
39,30	50,05	30,86
6,06	131,13	0,28
4,13	9,77	1,75
32,75	39,09	27,44
1,65	39,09	0,07
0,25	22,77	0,00
575,06	716,59	1040,38
Cosinus θ:		
0,67	26,77	32,25
Arccos θ (rad)	$\sqrt{\sum_{i=1}^{18} y_i^2}$	$\sqrt{\sum_{i=1}^{18} x_i^2}$
0,84		

Table A.5: Calculation of inner product of two vectors.  
Calculation of degrees between both vectors